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In This Issue

In the first issue of *Agricultural Economics Research* 38 years ago, O.V. Wells indicated that the new research periodical would publish articles (1) reporting results of economic research supported by the U.S. Department of Agriculture, (2) describing new methods or critically evaluating old methods still in use, and (3) describing new or expanding areas of research or statistics.

Most articles in this journal since then have been in the first category, reporting research results. Yet, the lead article in the new journal was "Designs of Samples For Surveys," by Earl E. Houseman, then a statistical consultant to the Office of the Chief, Bureau of Agricultural Economics (BAE), but later an employee of BAE and the Statistical Reporting Service and a frequent AER contributor. This fact is noteworthy because by leading with this article, the journal emphasized questions about designing samples for social science research. It also represented symbolically the crucial role of the statistician and sample surveys in supporting the quality of data used in economic research. The editor continued this emphasis, carrying eight articles on surveys and sampling questions in Volume 1, compared with seven articles on economic questions. Emphasis over the years shifted more toward economics articles, with the sampling and survey articles appearing in varying frequencies. Articles related to the survey and sampling techniques underlying our data base have been lacking in recent issues.

The recent void disappears with this issue's lead article in which Ford, Nealon, and Tortora compare sampling and nonsampling errors in area frame estimators in agricultural surveys. Reading this article *and* the Houseman article in Volume 1, Number 1, I was struck, not only by how far survey and sampling techniques have advanced in the three decades, but also by the similarity of the problems the two articles address.

The second article by Smale, Saupe, and Salant addresses the research question of using data from sample surveys of farm households in Wisconsin and Mississippi-Tennessee to gain insights into those human resource, farm business, and financial characteristics which contribute to farm household viability.

The final article by Ballenger and Norton departs from survey emphases and presents results of a large-sector model that simulates economic equilibrium. They use a quadratic programming framework for their economic model that analyzes the impacts of Mexican pricing policies on Mexican agriculture and that illustrates the difficulty of designing a support program for a sector when there are multiple policy objectives.

Gerald Schluter

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Area Frame Estimators in Agricultural Surveys: Sampling Versus Nonsampling Errors

Barry L. Ford, Jack Nealon, and Robert D. Tortora*

Abstract

This article describes and compares three area frame estimators used for agricultural surveys and shows the importance of sampling and nonsampling errors to both economists and statisticians. Comparisons among the estimators are based on their applicability, sampling efficiency, and susceptibility to nonsampling errors. The weighted segment estimator has the widest applicability and highest precision, but it also has important nonsampling errors. This article also discusses research conducted to evaluate and reduce the nonsampling errors.

Keywords

Area frame, closed segment estimator, open segment estimator, weighted segment estimator, nonsampling errors

Introduction

Probability surveys that make agricultural estimates often use an area frame. The area frame includes all the land within a specified geographical area, such as the continental United States, and is used to define the sample for a survey. Area frames have been used by the Statistical Reporting Service (SRS) since the early sixties. The June Enumerative Survey (JES), an annual survey which measures planted acreage of crops and numbers of livestock, is an example of a major survey which depends almost entirely on an area frame. Although the use of list frames for probability surveys has increased greatly in recent years, area frames are still needed to measure the incompleteness of the lists.

The Farm Costs and Returns Survey, measuring farm economic values, is an example of a survey that uses an area frame to measure the incompleteness of the list frames. In this case, the lists include only farms with gross sales greater than $100,000; thus, the sample from the area frame to measure the incompleteness of the lists is an essential part of the survey. The sample from the area frame contributes about 50 percent of the agricultural economic estimates. Area frame estimators are a crucial part of almost all probability surveys on which agricultural estimates are based.

SRS area frames are stratified in each State according to several factors, intensity of agriculture on the land being a primary factor. SRS selects a sample from each stratum. Each element of the sample is a continuous parcel of land called a segment. SRS draws the boundaries of each segment on an aerial photograph; enumerators use these photographs when collecting data.

After data collection, SRS uses three estimators: the closed, open, and weighted segment estimators. All three require that the enumerator establish what farms are related to each segment. (For SRS purposes, a farm is defined to be all land under one operating arrangement with gross farm sales of at least $1,000 a year.) The enumerator finds out what portion of the segment is under the operation of each farm. This portion is called a tract, and the enumerator draws the boundaries of each tract on the aerial photograph, accounting for all land in the segment.

*The authors are mathematical statisticians with the Statistical Reporting Service, U.S. Department of Agriculture. Ford is the Head of the Crops, Prices, and Labor Surveys Group, Estimates Division; Nealon is the Head of the Sampling Frame Development Section, Statistical Research Division; and Tortora is Director of the Survey Division.

When an enumerator interviews a farmer, the closed segment approach requires that the enumerator obtain data for only that part of the farm within the tract. For example, the enumerator might ask about the total number of hogs on the land in the tract.

The open segment and weighted segment approaches require that the enumerator obtain data on the entire farm. For example, the enumerator would ask about the total number of hogs on all land in the farm. However, the open segment approach uses these data only when the headquarters of the farm is within the segment boundaries. (Thus, the headquarters is used to identify each farm uniquely with one segment.)

Using the weighted segment approach, the enumerator obtains farm data for each tract, but these farm data are weighted; the current weight used by SRS is the ratio of tract acres to farm acres.

The formulas for the three estimators and their standard errors appear in the appendix at the end of this article.

Suppose the following situation occurs for a specific farm: tract acres = 10, farm acres = 100, hogs on the tract = 20, and hogs on the farm = 40. The closed segment value of number of hogs would be 20; the weighted segment value would be $40 \times (10/100) = 4$; and the open segment value would be 40 (if the headquarters is in the segment) or 0 (if the headquarters is not in the segment).

Comparing the Estimators

Economists and statisticians who wish to obtain data or understand the nature of a particular estimate should be familiar with the distinct advantages and disadvantages of the closed, open, and weighted approaches. This section compares each estimator with respect to its applicability, the size of sampling errors, and its susceptibility to nonsampling errors.

Applicability

One of the most common uses of closed segment estimates is to estimate crop acreages and livestock inventories. An enumerator accounts for all land in each tract by type of crop or use and for all livestock in the tract. The main disadvantage of the closed segment estimator arises when the farmer can report only values for the farm rather than for a tract which is a subset of the farm. For example, "How many tractors do you own?" can only be answered on a farm basis. Thus, the closed segment estimator is not applicable for many agricultural items. Economic items and crop production are two major examples which farmers find difficult or impossible to report on a tract basis.

The open and weighted segment estimators, by contrast, do not have this limitation. They can be used to estimate all agricultural characteristics. This broad applicability is a major advantage for both estimators.

Sampling Efficiency

Sampling efficiency refers to the precision and cost of the estimators. The precision of an estimate can be measured by: (1) the variance of the estimate, (2) the standard error which is the square root of the variance, or (3) the coefficient of variation (CV) which is the standard error divided by the estimate. An estimate becomes less precise as any of these measures increases.

Given the same number of segments to make each estimate, weighted segment estimates are usually more precise than closed segment estimates, and closed segment estimates are usually more precise than open segment estimates (*5, 6, 7*).[1]

Table 1 shows the variances of the three types of estimates from a data set collected in 1982. By comparing the estimated variances, the reader can see that the weighted segment estimates generally have smaller variances than the closed segment estimates, and the closed segment estimates have smaller variances than the open segment estimates. The reduced applicability of the closed segment estimator is clear by the fact that one cannot estimate the number of farms by using only tract information. Thus, there are no closed segment estimates for estimating the number of farms.

[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

Table 1—Estimated variances of open, closed, and weighted segment estimates for five farm characteristics, 1982

State	Segments	Estimate	Cattle and calves	Hogs and pigs	Corn acres	Soybean acres	Number of farms
	Number	*Type*	10^{10}				10^{7}
Georgia	436	Open	3.55	1.59	3.66	17.92	1.13
		Closed	2.70	2.88	.49	4.76	NCL
		Weighted	1.22	1.51	.60	3.91	.88
Indiana	324	Open	2.42	18.67	50.12	28.44	1.19
		Closed	2.35	19.74	4.78	4.14	NCL
		Weighted	.89	7.85	2.92	2.15	1.61
Missouri	450	Open	24.11	41.21	10.20	73.36	3.13
		Closed	12.07	29.59	3.75	9.43	NCL
		Weighted	5.20	8.10	2.22	6.88	2.60
North Carolina	391	Open	1.20	1.54	8.09	11.67	2.73
		Closed	.75	6.25	1.82	2.30	NCL
		Weighted	.52	2.35	1.46	1.62	2.12
Ohio	324	Open	6.19	7.81	31.38	20.13	2.16
		Closed	3.02	6.17	3.73	3.36	NCL
		Weighted	1.94	3.68	2.76	1.75	1.37
Total	1,925	Open	37.46	70.81	103.45	151.51	11.14
		Closed	20.89	64.62	14.58	23.98	NCL
		Weighted	9.76	23.48	9.97	16.31	8.58

NCL = Not calculable.

Why would these relationships among the variances occur? Open segment estimates use farm values. Thus, the amount of variability in the value of an agricultural item across the entire set of segments can be great. For example, many segments may have no farm headquarters and get a zero value for a certain agricultural variable; another segment may have one or two headquarters of large farms and get an extremely large value for the agricultural variable. The open segment estimate spreads the agricultural data unevenly throughout the segments.

A closed segment estimate spreads the data more evenly through the segments, and, thus, decreases the variance. For the combined five-State estimates in table 1, this result is especially true for corn and soybean acres, items related directly to land. However, for numbers of livestock, the closed segment estimates are not much better because livestock tend to be in herds or groups that will either be in the tract or not, often forcing the tract value to be either zero or a large value. A weighted segment estimate apportions the farm livestock according to the percentage of the farm acres in the tract. This effect causes the livestock data to be more evenly spread throughout the segments than for either the open or closed segment approaches.

Efficiency also involves the costs of data collection. Because each farmer operating a tract in the segment must be interviewed, the data collection costs for the closed and weighted segment approaches are approximately equal. The cost of collecting only tract data may be slightly less if contacting the farmer is difficult. In this case, the enumerator can usually observe the tract values because the tract boundaries can be established as the enumerator works the rest of the segment. In contrast, the weighted segment estimates require farm values which are much more difficult to observe, and the enumerator would have to put more time into contacting the farmer. How-

ever, this cost difference would be slight compared with overall survey costs. Thus, the reader should consider the closed and weighted segment estimates as having the same costs.

An open segment estimate does not require interviewing all farmers with tracts in the segment, but only requires interviewing farmers whose headquarters are located in the segment. Depending on factors such as the dispersion of the sample and the size of farms, the costs of obtaining data for open segment estimates can be 5-20 percent less than for closed or weighted segment estimates. Thus, the open segment approach has a cost advantage, but less precision. To make the open segment estimates as precise as weighted segment estimates would require more segments to be enumerated. Depending on what agricultural item is estimated, the extra cost of these segments may or may not exceed the advantage of a lower cost per segment for the open segment estimates.

Nonsampling Errors

Whereas precision relates to the sample size and the variability of the data, nonsampling errors refer to the effects of biases in the data or estimators. For estimates from large-scale surveys, and agricultural surveys are no exception, nonsampling errors may be of more concern than precision because such errors are harder to control.

Closed Segment Estimates

An accurate measure of the total number of acres within each segment is available prior to interviewing because each segment is delineated on aerial photographs. This measurement provides a control on the total land within the segment accounted for by the enumerator, and it increases the accuracy of the closed segment estimates for crop acreages.

Two types of nonsampling errors occur for closed segment estimates. The first type occurs because there are small areas of waste within the fields. Because of the scale of a photograph, accounting for areas of waste less than 1 acre is particularly difficult. These small waste areas are usually not visible on the photograph and generally cannot be observed from the actual location of the interview. The second type of nonsampling error occurs in some Western States where cattle and sheep roam freely through open gates and cross tract or segment boundaries. In these situations, the operator may not know the exact location of the livestock at the time of the interview and, thus, may not be able to report exactly how many livestock are on the tract at that time. Neither of these types of nonsampling errors is considered serious because research studies have never shown that a consistent positive or negative bias has resulted.

A major advantage of closed segment estimates is their ability to decrease any bias caused by nonresponse. When the farmer refuses to supply information or is inaccessible, the enumerator can usually observe the crops and livestock in the tract. The acreages associated with the crops can be measured from photographs. Often the livestock can be counted; even when they cannot, an indication of their presence allows SRS to do a better job of adjusting for nonresponse (*4*).

Open Segment Estimates

Four important nonsampling errors are associated with open segment estimates. The first is caused by the incorrect application of the "headquarters" rule. Although application of this rule is straightforward for farms run by individuals, the identification of headquarters can become difficult for partnerships, corporations, and managed farms where enumerators need to ask a series of questions to eliminate potential duplicate reporting. SRS has never been able to measure fully the effects of this nonsampling error on the estimates, but it has developed better questionnaires and has stressed the problem during enumerator training to minimize the effects.

The second nonsampling error is the underestimating of the farm population. This error probably arises because the headquarters of farm operators may be inadvertently missed in more densely populated areas. For most farmers, the headquarters is the home, and if the home is in town or in a subdivision, an enumerator may have difficulty identifying that home as the residence of a farmer, especially if the farmer does not consider farming as the primary occupation. Other factors may contribute to this underestimation.

The third nonsampling error is the underreporting of farm values. The reader should consider the effect on a farmer when interviewed by an enumerator. To obtain tract values, the enumerator shows the farmer an aerial photograph on which the precise boundaries of the farmer's tract are drawn. Then the farmer is asked to report values associated with that specific piece of land. When farm values are obtained, there is no map. Both enumerator and farmer must switch into the more nebulous concept of "the farm," that is, the land operated by this farmer. Farmers tend to forget about parcels of rented land not contiguous with the main part of their farm and about parcels of woodland or wasteland under their control, but considered "nonagricultural."

A fourth nonsampling error can occur when the farmer reports livestock data. The enumerator asks the farmer about livestock on the land operated *regardless* of the ownership of the livestock. However, a farmer tends not to report livestock on the farm that are owned by someone else. This typically happens when the farmer is feeding livestock (under contract) owned by someone else. A farmer also tends to report livestock owned by the farmer, but located on someone else's land.

Weighted Segment Estimates

This section is more detailed and quantified than the previous two sections because of the large amount of SRS research to evaluate the nonsampling errors of the weighted segment estimates. SRS believed that the research was warranted because of the advantages in applicability and precision of weighted segment estimates over closed and open segment estimates. This research began when SRS reinterviewed a subset of respondents after the 1974 JES (*3*). Respondents were again asked many of the JES questions about their farms and were then asked to reconcile any differences between the original JES responses and their responses during the reinterview. The evaluation, which was small in scope, involved reinterviews with only 163 JES respondents in Nebraska.

Comparing the original weight with the reconciled weight, SRS found 44 differences out of the 163 reinterviews (27 percent) caused by incorrect responses. Exactly half the differences were positive and half were negative. The effect of the reconciled weights on the weighted segment estimates of hogs and cattle caused biases of –9.6 percent and –0.2 percent, respectively.

SRS also estimated the biases associated with the components of the weighted segment estimates. The estimated biases were as follows: acres in the tract, 0.3 percent; acres in the farm, –5.6 percent; hogs on the farm, –2.5 percent; and cattle on the farm, –2.4 percent. Thus, the concept of farm acres caused the largest bias.

The results of the 1974 JES reinterview were sufficiently troubling that SRS planned a detailed reinterview with a large sample size after the 1976 December Enumerative Survey (DES). The DES reinterview involved 528 respondents in three States: Indiana, North Carolina, and Oklahoma. Table 2 shows the biases in weighted segment estimates for hogs and cattle in the three States and the significance levels from statistical tests of whether the biases were significantly different from zero.

Table 2—Estimated bias in the weighted segment estimates for hogs and cattle and the alpha level from each statistical test, 1976

State	Interviews	Hogs and pigs		Cattle and calves	
		Bias	Alpha level	Bias	Alpha level
	Number	*Percent*		*Percent*	
Indiana	149	–11.7	0.15	–4.5	0.02
North Carolina	172	–16.9	.01	–.3	.96
Oklahoma	207	2.2	.42	–3.4	.36
Total	528	–10.9	NA	–3.0	NA

NA = Not available.

When investigating biases in the components of the weighted segment estimates, SRS found that problems in the denominator of the weight—farm acres—were the most serious. For the three States, 44 percent of the farmers who were reinterviewed reported a different number of farm acres. These differences were not offsetting and resulted in the following estimated biases for the farm acres that had been collected on the DES: Indiana, –2.9 percent; North Carolina, –9.9 percent; and Oklahoma,

–4.8 percent. Thus, a farmer tended to underreport the acres in the farm, a result which was consistent with the 1974 reinterview study in Nebraska.

This DES study also obtained the reasons for differences between the original responses and the reinterview responses. Of the differences, 19 percent occurred because the farmer estimated the acreage rather than taking the time to account for the exact acres in the farm. Fifteen percent of the differences were caused by problems in reporting parcels of woodland or idleland which had no crops or livestock. Thirteen percent of the differences involved land rented by or rented out by the farmer. Thirteen percent involved farmers who simply miscounted their acreage. Eight percent could only be attributed to the fact that a different respondent participated in the reinterview than in the DES. The remaining 32 percent reflected miscellaneous reasons such as inclusion of land that was to be sold in the near future, incorrect readings of JES photographs, and farmers who did not remember the initial JES interview.

The authors of the study decided that the underreporting of parcels of woodland or idleland was the main reason for the negative biases in reporting farm acres (*8*). Parcels of woodland and idleland mixed into the agricultural land were more typical of farming conditions in North Carolina (a bias of –9.9 percent in farm acres) than in Indiana (a bias of –2.9 percent in farm acres). The other major reasons for differences caused both negative and positive differences in the farmers' responses, while omission of parcels of woodland and idleland always caused a negative difference.

Panel discussions with enumerators in seven States before the 1982 JES confirmed the problem of obtaining accurate farm acres on the JES:

> Interviewers consider this section to be one of the hardest to get correct answers on; intensive probing is often required. Respondents often do not know the exact acreages offhand. Many operators report only cropland, omitting other types of land such as woodland and wasteland. (*12*)

In summary, closed segment estimates would be the best to use except that their restricted applicability can be an insurmountable problem for survey designers. Thus, weighted segment estimates appear to be the best alternative if the costs are not prohibitively high when compared with the costs of the open segment estimates. SRS now uses all three estimates for its JES because no one type of estimate is clearly the best for every agricultural item estimated by the survey. However, this situation adds more burden on the respondent and greater complexity to the questionnaire.

Research on Alternative Weighted Estimators

How can weighted segment estimates be improved? SRS has recognized that the prevention of nonsampling errors, especially trying to get farmers to give exact acreages rather than best guesses, is extremely difficult. Thus, SRS has decided to concentrate its research on the investigation of alternative weighting schemes for the weighted segment estimator.

Weights Defined by Agricultural Land

SRS evaluated an alternative weighting scheme in 1980 based on total land minus woodland, wasteland, and other nonagricultural land. This weight should have been less susceptible to bias than the operational weight because it subtracted from the numerator and denominator the type of land that was the major source of bias with the operational weight.

The operational and alternative versions of the weighted segment estimator were compared in three States during the 1980 JES for three important farm characteristics: number of farms, total cattle, and total hogs. Table 3 shows the relative difference between the two types of weighted segment estimates for each of the three farm characteristics. The differences between the two estimates were quite small in most instances. Thus, the study did not show that the alternative weight was less biased than the operational weight.

Some nonsampling errors associated with the alternative weight surfaced during the study. The most serious error centered on a discrepancy when farmers reported nonagricultural land at the tract level and the farm level. At the tract level, farmers were instructed to exclude not only woods and other blocks of nonagricultural land but also waste within

Table 3—Relative difference between operational and alternative weighted segment estimates, 1980

State	Segments	Relative difference[1] Number of farms	Cattle and calves	Hogs and pigs
	Number	*Percent*		
Minnesota	343	3.5	0	–0.5
Ohio	324	3.3	4.7	–2.5
Wisconsin	310	1.0	–1.2	–.1
Total	977	2.6	.3	–.8

[1]Relative difference = 100 (alternative-operational)/operational.

an agricultural field. The author of that study concluded that when reporting for the farm, farmers did not exclude small parcels of waste within agricultural fields (*2*). Therefore, some nonagricultural land was included in the denominator of the weight, producing an downward bias in the alternative weight.

SRS tested a modified alternative weight in five States during the 1981 JES. This modified weight did not include within-field waste. The estimates were compared between the operational and alternative weighted segment estimates for the same three farm characteristics evaluated in 1980. The estimates were remarkably similar again. The alternative weighting scheme was not less susceptible to an upward bias than the operational scheme. Numerous nonsampling errors associated with the alternative weight were identified during the studies (*9, 10*). Thus, SRS decided to investigate a less complex alternative weight.

Weights Defined by Cropland

SRS collected data on cropland weights during the 1982 JES in five States. Cropland was defined as land planted or to be planted to crops during 1982, idle cropland, summer fallow, and cropland used only for grazing or pasture. Field waste was excluded from the cropland acreage for both the tract and farm to avoid the problems encountered during the 1981 study.

Eleven percent of the farms in the five States had no cropland. Cropland acreage for the farm was missing for another 12 percent of the operations. SRS adjusted the estimation procedures to account for the data on these operations. Thus, the cropland weight quickly ran into problems that annoyingly complicated the estimation.

The relative differences between the two types of weighted segment estimates are shown in table 4. The significance level from the paired t-tests comparing the estimates are also shown because there were many significant differences. The estimates for the number of farms and cattle inventories were significantly higher for the operational estimates in Georgia, Missouri, and North Carolina and for the total combined. These results indicate that the cropland weight is less susceptible to an upward bias than the operational weight. The three States with considerably more noncropland—Georgia, North Carolina, and Missouri—were the States where the two types of weighted segment estimates were significantly different.

In reporting on their 1982 research, Dillard and Nealon concluded that the cropland weight did not appear to be as biased as the operational weight (*5*). Two disadvantages of the cropland weights were that: (1) 23 percent of the operations had cropland that was either zero or missing, and (2) the CV's were slightly higher for the estimates using the cropland weight.

Further Research

SRS will continue attempting to reduce the nonsampling errors of the weighted segment estimator that is used operationally. The applicability of this estimator plus its high precision call for this continued research. The agency will also test new weighting schemes. The most recent research proposal is to weight by the size of the major agricultural item of each farm (*1*). If a farm has cropland, the major item will be the crop with the most acreage. If a farm has no cropland, the major item will be the type of livestock that are most numerous. Preliminary research has indicated an optimistic outlook for this estimator.

Statisticians still tend to compute sampling errors and make their decisions based only on them. In the case of SRS, the weighted segment estimator was implemented operationally almost as soon as

Table 4—Relative difference between the operational and alternative weighted segment estimates and the alpha level from each statistical test, 1982

State	Segments	Number of farms		Cattle and calves		Hogs and pigs	
	Number	*Relative difference*	*Alpha level*	*Relative difference*	*Alpha level*	*Relative difference*	*Alpha level*
Georgia	436	–7.4	0.01*	–19.4	0.01*	2.2	0.83
Indiana	324	.3	.81	–2.0	.38	.6	.76
Missouri	450	–5.3	.01*	–10.8	.01*	2.2	.67
North Carolina	391	–13.0	.01*	–29.6	.01*	1.9	.80
Ohio	324	–2.4	.07	–5.3	.09	.8	.79
Total	1,925	–5.5	.01*	–11.3	.01*	1.1	.63

*Denotes a significant difference at the 0.05 alpha level. Relative difference = 100 (cropland-operational)/operational.

SRS observed the decreased variance. However, 10 years after research began, SRS is still trying to identify and eliminate the nonsampling errors involved (*11*). The overall effect of SRS's research is to illustrate the importance and difficulty of assessing nonsampling errors when one searches for the "best" estimator. First, identifying all the nonsampling errors that come, often subtly, into play is difficult. Second, once identified, nonsampling errors are extremely difficult to measure. The very studies designed to assess the effects of the nonsampling errors will have their own nonsampling errors. Third, once measured, nonsampling errors may be difficult (or impossible) to prevent or correct. For survey designers, working with nonsampling errors can be a tortuous obstacle course.

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Appendix: Formulas for the Area Frame Estimators

Each area frame estimator can be described by the following notation. For some characteristic, Y, of the farm population, the sample estimate of the total for the closed segment estimator is:

$$Y_c^* = \sum_{i=1}^{s} \sum_{j=1}^{p_i} e_{ij} \sum_{k=1}^{n_{ij}} y_{ijk} \qquad (1)$$

where:

s = the number of land-use strata;

p_i = the number of substrata in the i^{th} stratum;

n_{ij} = the number of segments sampled in the j^{th} substratum in the i^{th} stratum;

e_{ij} = the expansion factor or inverse of the probability of selection for each segment in the j^{th} substratum in the i^{th} stratum;

$$y_{ijk} = \begin{cases} \sum_{m=1}^{f_{ijk}} t_{ijkm} & \text{if } f_{ijk} > 0 \\ 0 & \text{if } f_{ijk} = 0 \end{cases} \qquad (2)$$

f_{ijk} = the number of tracts in the k^{th} segment, j^{th} substratum, and i^{th} stratum, and

t_{ijkm} = the tract value of the characteristic, Y, for the m^{th} tract in the k^{th} segment, j^{th} substratum, and i^{th} stratum.

For the open segment estimator, the sample estimate would be the same form as Y_c^*:

$$Y_o^* = \sum_{i=1}^{s} \sum_{j=1}^{p_i} e_{ij} \sum_{k=1}^{n_{ij}} y_{ijk} \qquad (3)$$

except here:

$$y_{ijk} = \begin{cases} \sum_{m=1}^{f_{ijk}} b_{ijkm}\, y_{ijkm} & \text{if } f_{ijk} > 0 \\ 0 & \text{if } f_{ijk} = 0 \end{cases} \qquad (4)$$

b_{ijkm} = 1 if the farm headquarters is within the segment
0 if the farm headquarters is not within the segment

y_{ijkm} = the value of the entire farm for the m^{th} tract in the k^{th} segment, j^{th} substratum, and i^{th} stratum

The weighted segment estimator would also be of the same form:

$$Y_w^* = \sum_{i=1}^{s} \sum_{j=1}^{p_i} e_{ij} \sum_{k=1}^{n_{ij}} y_{ijk} \qquad (5)$$

but with the distinction that:

$$y_{ijk} = \begin{cases} \sum_{m=1}^{f_{ijk}} a_{ijkm}\, y_{ijkm} & \text{if } f_{ijk} > 0 \\ 0 & \text{if } f_{ijk} = 0 \end{cases} \qquad (6)$$

a_{ijkm} = the weight for the m^{th} tract in the k^{th} segment, j^{th} substratum, and i^{th} stratum.

Operationally, SRS has used the weight:

$$a_{ijkm} = \frac{\text{tract acres for the } m^{th} \text{ tract}}{\text{entire farm acres for the } m^{th} \text{ tract}} \qquad (7)$$

since the early seventies.

For all three estimators, the formula for the estimated variance can be written as:

$$\mathrm{Var}\,(Y^*) = \sum_{i=1}^{s} \sum_{j=1}^{p_i} \frac{(1-\frac{1}{e_{ij}})}{(1-\frac{1}{n_{ij}})} \sum_{k=1}^{n_{ij}} \left(y'_{ijk} - y'_{ij\cdot} \right)^2 \quad (8)$$

where:

$$y'_{ijk} = e_{ij}\, y_{ijk} \quad (9)$$

$$y'_{ij\cdot} = \frac{1}{n_{ij}} \sum_{k=1}^{n_{ij}} y'_{ijk} \quad (10)$$

The standard error is then:

$$SE(Y^*) = \{\mathrm{Var}\,(Y^*)\}^{1/2} \quad (11)$$

In Earlier Issues

This fact that a sample can be more accurate than a census, under certain conditions, is becoming widely accepted. The explanation is simple. With the exception of rather unusual cases, surveys and censuses are subject to many errors which have little, if anything, to do with the way a sample is selected. The challenging problem is often how to get accurate and useful information from respondents, or how to keep errors due to causes other than sampling at a minimum—not how to design an efficient and adequate sample.

Earl E. Houseman
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Farm Family Characteristics and the Viability of Farm Households in Wisconsin, Mississippi, and Tennessee

By Melinda Smale, William E. Saupe, and Priscilla Salant*

Abstract

The authors used data from sample surveys of farm households in Wisconsin, Mississippi, and Tennessee to examine the relationship of farm household viability to human resource, farm business, and financial characteristics. Viability is measured as the ratio of farm and nonfarm income to consumption expenses, capital replacement costs, and principal payments. Households are grouped by region, gross sales, farm type, operator off-farm employment, and farm business plans. Regression results indicate that factors associated with viability differ by household group. Farm size is associated positively with viability only for larger full-time farmers in Mississippi and Tennessee and for households planning to leave farming.

Keywords

Farm viability, family farms, farm households, Wisconsin, Mississippi, Tennessee

Introduction

The incidence of financial stress among farm families differs by farm type, maturity of operation, and organizational factors; in fact, the overall failure rate of farm businesses is severe and threatens the continued existence of many family farms. In October 1984, one-fourth of the farm loan portfolio of the Farmers Home Administration was delinquent (*1*).[1] In 1984, about one-fifth of all farmers had debt-asset ratios above 40 percent, a level indicating severe debt-repayment difficulties. One-third of farmers with annual sales over $40,000 had debt-asset ratios higher than this critical level. These operations were large- and medium-size farms, and most were full-time family farms (*2*).

In this study, we used cross-sectional data from farm household surveys in Wisconsin, Mississippi, and Tennessee to examine the viability of individual farm households. Farm business and household characteristics are reported for selected groups of farm households, by survey region. We tested characteristics hypothesized to be associated with farm viability and compared groups using regression analysis.

This study provides new information on the characteristics of farm families and factors affecting their financial condition. The analysis uses farm family data from selected areas in Wisconsin, Mississippi, and Tennessee to measure the viability of individual farm households. We grouped farm households by major organizational attributes and tested the effects of differences in human resource, farm business, and financial characteristics on a farm's potential for success. For the Wisconsin area, selected groups include households that operate dairy farms. For both the Wisconsin and Mississippi-Tennessee survey areas, selected groups include

*Smale was a research specialist with the Department of Agricultural Economics, University of Wisconsin-Madison; Saupe is a professor in the Department of Agricultural Economics, University of Wisconsin-Madison/Extension; and Salant is an economist with the Agriculture and Rural Economics Division, ERS. This research was supported by the USDA project, "Social and Economic Characteristics of U.S. Family Farms," the Research Division, College of Agricultural and Life Sciences, University of Wisconsin-Madison, and by University of Wisconsin-Extension.

[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

households in which the operator farms part-time, households with smaller farms (annual sales under $20,000), households with larger farms (annual sales $20,000 or above) on which the operator farms full-time, and households in which the operator is planning to leave farming.

USDA's 1981 and 1983 Family Farm Surveys were designed to link farm business data with characteristics of the family on the farm. The surveys studied and gathered new information about the characteristics of farm families, family labor use, farm business organization, farm financial characteristics, sources of household income, and perceived problems and goals of farm families. Data revealing characteristics of both the farm family and the farm as a producing unit are not generally available through other USDA series or the *Census of Agriculture* or *Census of Population.*[2]

The Mississippi-Tennessee Family Farm Survey (1981) covered 1,087 households in a contiguous 29-county area in northern Mississippi and southwestern Tennessee (*3*). The Wisconsin Family Farm Survey (1983) covered 529 farm households in an eight-county area in southwestern Wisconsin (*4*).

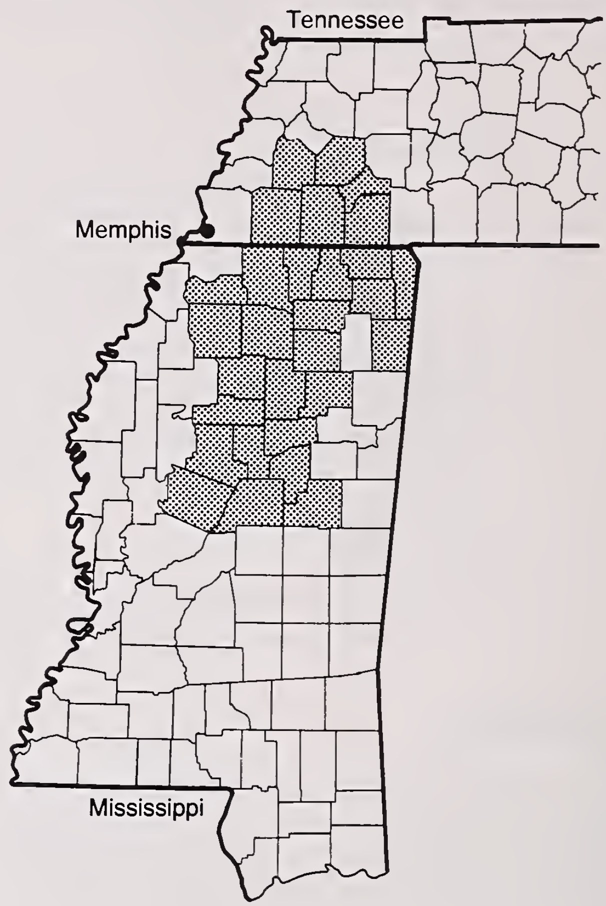
Although survey results can be generalized only to the counties included in the samples, the survey sites were selected because they share common features with larger segments of U.S. agriculture. The southern site typifies parts of the Southeast and Piedmont, where farming is an important economic activity, but farms are relatively small. The Wisconsin site is typical of other North Central and New England areas where dairying is the most common farm type and most farms are family enterprises.

The Mississippi-Tennessee site lies in the Sand-Clay Hills region, a low-income agricultural area dominated by small farms (fig. 1). Most of these small farms are beef cattle operations (excluding feedlots), with some soybean, cash grain, and cotton enterprises. The metropolitan area of Jackson, TN (population of 50,000), and a number of smaller towns (populations under 12,000) provide some off-farm employment.

[2]An exception is the "1979 Farm Finance Survey," a followup to the *1978 Census of Agriculture*.

Figure 1

Mississippi-Tennessee Family Farm Survey Site

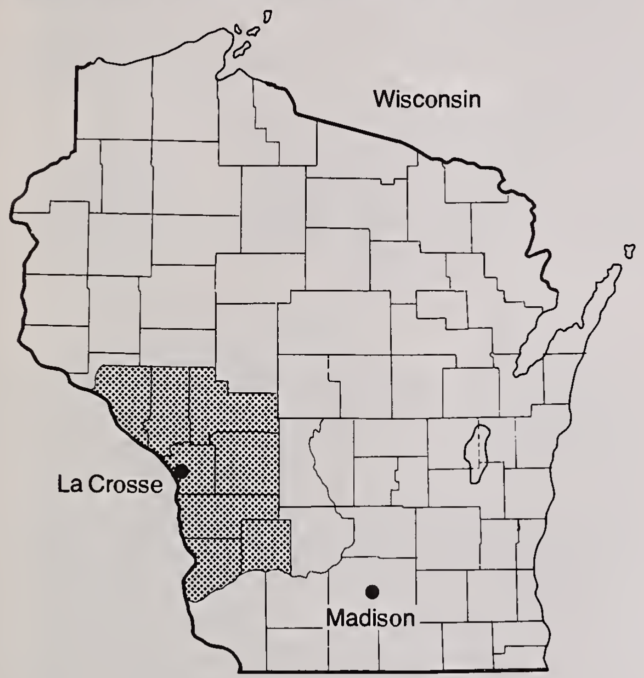


The Wisconsin site is in the unglaciated hills of the southwestern portion of the State (fig. 2). A low-income area in relation to the State, the site is not depressed according to national criteria and has a higher average income than the Mississippi-Tennessee survey area. About two-thirds of the Wisconsin farms are dairy operations, and the remainder are cash grain, beef cattle, and other livestock operations. LaCrosse (population of 51,000) and four smaller towns (populations between 5,000 and 6,200) provide some off-farm employment opportunities.

Roughly 12,000 farm households were represented in each site. The sample was drawn with a stratified two-stage cluster design in the Mississippi-Tennessee

Figure 2

Wisconsin Family Farm Survey Site



site and was selected at random from a list of operators in Wisconsin. In both areas, households were contacted to determine whether they qualified as "family" farms, and only eligible households were included in the survey. A farm was defined as a business producing at least $1,000 of agricultural sales in a normal year. The farm was considered a "family" farm if it was not operated by a hired manager, a nonfamily corporation, or an institution.

Trained enumerators conducted personal, onfarm interviews with the farm operator, identified by the household members as the person responsible for major administrative, managerial, and daily operating decisions.

Method

To survive each year, a farm household must generate annual cash income sufficient to provide for the livelihood of its members. To continue operating the farm business, as currently organized, the farm household must cover cash expenses associated with farm production and regularly replace capital stock to sustain the stock's serviceability. To maintain its line of agricultural credit, the farm household must also meet scheduled payments toward loan retirement. Meeting consumption expenses, production expenses, capital replacement costs, and interest and principal payments is a minimum financial obligation for the year-to-year survival of the farm household.

This study's unit of observation is the household of a farm operator, and the accounting period corresponds to 1 year. Because the household's minimum financial obligations toward consumption, production, replacement of capital stock, and loan retirement must be met with cash expenditures, the authors used a cash concept of household income. The cash income concept excludes farm inventory changes and the imputed rental value of the farm residence. The income and expenditure concepts and terminology of this study are consistent with those used in the U.S. Department of Agriculture's (USDA) income accounts series (*5*, pp. 1-5).

The economic activity common to the survey households is the operation of a farm business. The earnings of the farm business are measured as net cash income from farming. Net cash income from farming is calculated as the sum of cash marketings of crops, livestock, and products, plus Government payments and other farm income from machine hire and recreation, minus intermediate product expenses of farm origin (such as feed) and nonfarm origin (such as fertilizer), business taxes, business interest, cash wages, and rent paid. In addition to net cash income from farming, survey households receive (1) off-farm employment income from wages and salaries and (2) unearned income (such as nonfarm asset income and transfers). These latter sources of income are important for many of the farm households surveyed; on small, part-time operations, off-farm employment may constitute the primary source of income.

From these combined sources of net cash income, each household must meet annual consumption, capital replacement, and loan retirement obligations. Annual consumption expenditures include the costs of basic needs such as food, clothing, and health care, the timely replacement of consumer

durables, and payment of income and Social Security taxes. In this study, we used Federal poverty-level income criteria as a measure of minimum consumption needs.[3] Annual cash expenditures to maintain capital stock represent the replacement of obsolete or damaged capital. These annual replacement costs are distinct from investment to expand the productive capacity of the farm business. In this study, estimated capital replacement costs were calculated at 10 percent of the value of all farm machinery, trucks, and cars. We calculated loan retirement payments, or estimated principal payments, on the basis of the type of collateral under which individual loans were secured (see the glossary at the end of this article).

If the farm household's combined sources of income, as previously defined, are adequate to meet these minimum financial obligations, both the farm business unit and the farm household as a consuming unit are viable. The authors define "viability" as a level of annual cash income sufficient to cover farm operating costs, meet the household's minimum consumption needs, replace capital items at a rate that ensures constant serviceability of the capital stock, and finance loan retirement as scheduled. Under this definition, a viable farm household will both survive and enhance its equity position through retiring loans. If total cash income from combined farm and nonfarm sources exceeds minimum financial obligations, the balance can be used to increase consumption, invest in human capital, expand the farm business, or accumulate nonfarm savings or investments.

To measure farm household viability, we developed a "viability ratio," which expresses the capacity of the farm household to meet minimum financial obligations, under the survey-year business and labor organization of the household.[4]

The ratio is generally constructed as follows:

$$\text{viability ratio} = \frac{\text{annual household net cash income}}{\text{annual household financial obligations}}$$

[3]The poverty-level income criteria are based on the cost of a nutritionally adequate diet plus a proportional allowance for other consumption items, adjusted by family size. Poverty-level income represents a minimal level of consumption. In 1983, for example, poverty-level income was about $10,000 for a family of four. At that level, the household could probably neither save nor invest in self-improvement.

The composition of terms in the viability ratio is determined by the household's farm business plans, as stated by the family in the survey. For families intending to continue farming over the 5 years following the survey, the ratio compares observed household income with an estimated minimum level required to satisfy consumption requirements, replace capital to maintain the serviceability of farm capital stock, and meet loan retirement payments as scheduled. The viability ratio for these households is constructed as follows:[5]

$$\frac{\begin{array}{c}\text{annual}\\ \text{household}\\ \text{cash income}\end{array}}{\begin{array}{c}\text{annual}\\ \text{financial}\\ \text{obligations}\end{array}} = \frac{\begin{array}{c}\text{net cash income from farming}\\ \text{+ off-farm employment}\\ \text{income + unearned income}\end{array}}{\begin{array}{c}\text{estimated minimum consump-}\\ \text{tion + estimated capital replace-}\\ \text{ment costs + estimated loan}\\ \text{principal payments}\end{array}}$$

This ratio compares total household income with the financial obligations the household must meet to continue operating as a farm business and as a farm family. Among farm households planning to continue farming, households with a ratio greater than or equal to 1.0 will be able to maintain their current (survey-year) operation. Those with a ratio less than 1.0 will be unable to meet all their obligations without making adjustments.[6]

For farm families intending to leave farming during the 5 years following the survey year ("farm exit households"), the viability ratio compares estimated total household income with the household's minimum consumption requirements. These households are assumed to retire all outstanding debt by liquidating assets. Thus, they are no longer obligated to make principal payments. Because they are no longer farming, they also have no obligation to replace capital. The viability ratio for farm exit

[4]This condition is imposed because the net effect of a change in labor allocation or business organization is difficult to predict. Households under financial stress will probably adjust the size or organization of the farm business. These adjustments may also be accompanied by changes in the allocation of household labor, both among members and between farm and off-farm work. Although these changes will probably alter net income, the magnitude of the changes cannot be estimated without additional information.

[5]Components of the ratio are defined in the glossary.

[6]Although these households may continue to operate in the short run by foregoing capital replacement, for example, they will not be able to survive in the long run under the year-of-survey business and labor organization of the household.

households relates the sum of estimated annual income from the value of net worth, estimated wage income, estimated Social Security benefits, and observed transfer payments to estimated minimum consumption, as follows:

$$\frac{\text{annual household cash income}}{\text{annual household obligations}} = \frac{\text{estimated annual income from value of net worth + estimated wage income + estimated Social Security payments + transfer payments}}{\text{estimated minimum consumption}}$$

Farm exit households with a ratio greater than or equal to 1.0 will be able to satisfy minimum consumption requirements if they cease farming. Those with a viability ratio of less than 1.0 will have difficulty meeting minimum consumption requirements if they cease farming under the current (survey year) business and labor organization of the household.

Identifying Household Groups

Farm households differ in terms of the characteristics that determine their viability. For the household surveyed, these characteristics include primary commodity produced, size of the farm operation, importance of farm and off-farm sources of income, and farm business objectives.

To control for the effects of these attributes on variability in the viability ratio, we grouped sample households into mutually exclusive categories consisting of: (a) farm households in which the operator is planning to leave farming (each survey area), (b) dairy farm households (Wisconsin area only), (c) households in which the operator farms part-time (each survey area), (d) households with a full-time operator and gross sales under $20,000 (each survey area), and (e) households with a full-time operator and gross sales of at least $20,000 (each survey area).[7] The logic of household selection is illustrated in figure 3.

[7]Operators who worked at least 160 hours off-farm during the survey year are classified as "part-time." Those who worked fewer than 160 hours off-farm during the survey year are classified as "full-time."

Criteria for sorting sample households were developed so that within-group differences in human resource and farm business characteristics were minimized and between-group differences were maximized. In the case of part-time farmers, for example, we tested several alternative definitions to create groups homogenous in terms of operator age and education as well as farm type. We made similar tests in defining "smaller" and "larger" farms with full-time operators.

Because agricultural production processes, human resource characteristics, and nonfarm labor markets differ between the two areas, we disaggregated data by survey region within each farm household group. Differences in farm household characteristics between the survey regions also suggest that data from the two sites are better analyzed separately.[8]

Profiles of Farm Household Groups

Table 1 shows selected human resource, farm business, and financial characteristics of the sample households by region and household group. The data demonstrate observable differences among groups in the level and composition of these resources.[9]

Dairy Farm Households

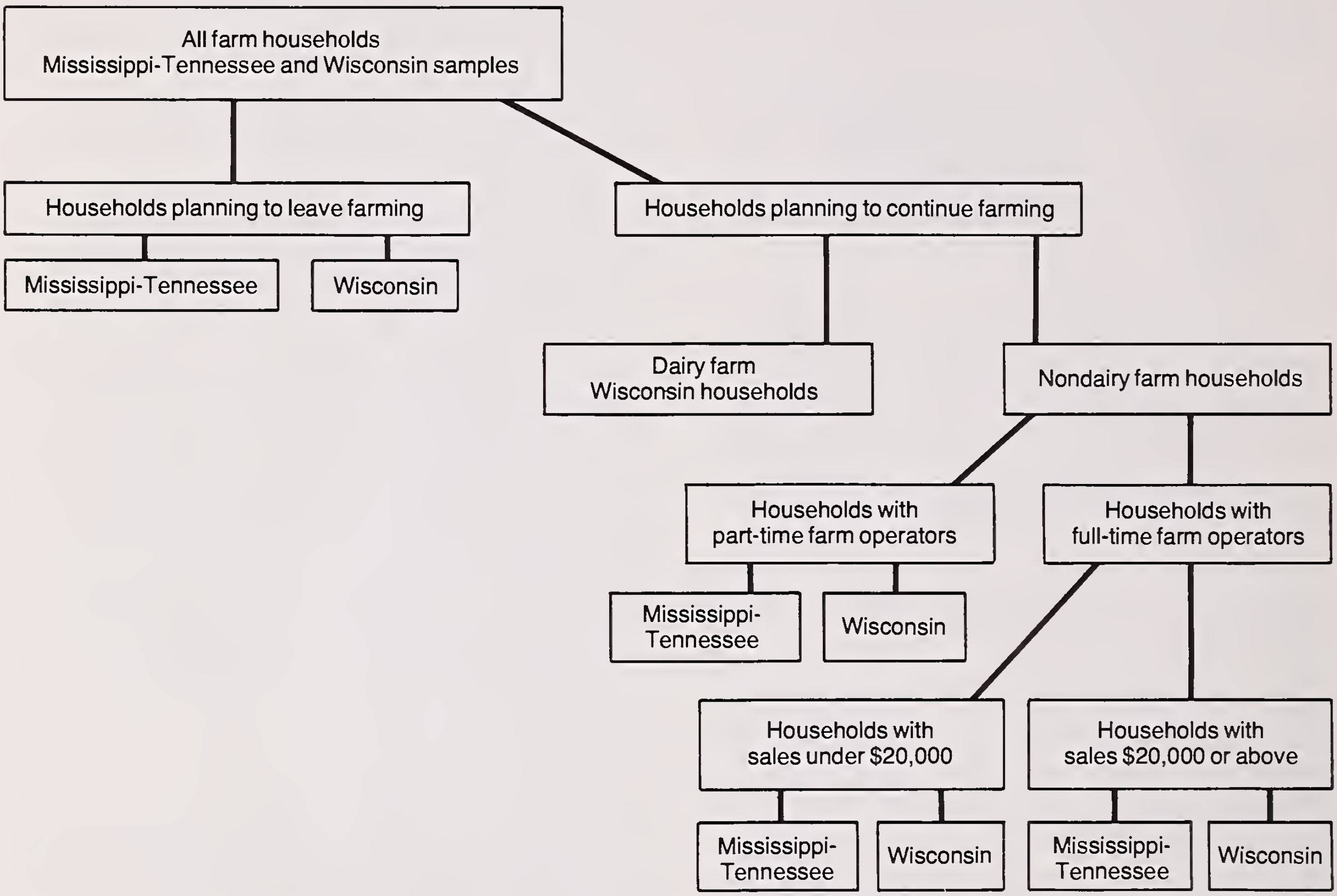
The average Wisconsin-area dairy farmer was 44 years old. Dairy farms produced average gross sales of $84,916 in 1982, with 191 crop acres and 45 cows. Farm families controlled an average of $368,991 in total assets and $273,061 in net worth. Dairy farm households had an average debt-asset ratio of 0.26. They received 75 percent of their total income from the farm business and approximately 15 percent from off-farm employment. Although these households reported an average total net income of $28,176, 47 percent had viability ratios under 1.0.

[8]Differences among household types are documented in "Farm Viability: Results of the USDA Family Farm Surveys," by Priscilla Salant, Melinda Smale, and William Saupe, U.S. Dept. of Agr., Econ. Res. Serv., forthcoming.

[9]Two-tailed difference-of-means tests were conducted at the 0.05 significance level. In the text, stated differences reflect the results of two-tailed statistical tests. Statements of relative magnitude do not reflect statistical tests because there was no *a priori* justification for one-tailed tests.

Figure 3

Selection of Farm Household Groups



Households with Part-Time Operators

Part-time farmers were defined as operators who worked off-farm at least 4 weeks per year. Financial and farm-size characteristics of part-time farmers were comparable between the two survey areas. Households in the Wisconsin area had an average net worth of $166,174 by the survey year, with a mean debt-asset ratio of 0.18. Households in the Mississippi-Tennessee area had an average net worth of $145,718 and a mean debt-asset ratio of 0.13. Farms in both survey sites were relatively small in terms of sales and acreage.

Although their high cash operating expenses contributed to negative net farm earnings, Wisconsin households received more off-farm employment and unearned income than those in the Mississippi-Tennessee area. On average, households with part-time operators received total income of $27,495 in Wisconsin and $23,072 in the Mississippi-Tennessee area. Over 80 percent of household income in both areas came from nonfarm sources. Less than 20 percent of all households with part-time operators had viability ratios under 1.0.

Table 1—Selected characteristics of nine farm household groups, 8-county Wisconsin area and 29-county Mississippi-Tennessee area

Item[1]	Unit	Dairy farmers	Part-time farmers		Full-time farmers				Farm exit	
					Sales under $20,000		Sales $20,000 or above			
		Wisconsin	Wisconsin	Mississippi-Tennessee	Wisconsin	Mississippi-Tennessee	Wisconsin	Mississippi-Tennessee	Wisconsin	Mississippi Tennessee
Farm households represented	Number	6,850	1,665	5,115	715	2,130	835	2,155	2,175	1,680
Sample households	do.	296	72	445	31	212	36	202	94	167
Human resource:										
Operator, age	Year	44.1	50.1*	47.3*	64.7	62.5	47.3	46.8	60.1*	63.2*
School completed	do.	11.6	12.3	11.6	9.7	8.7	11.5	11.7	9.9*	9.1*
Farming experience	do.	17.6	17.9	17.7	35.1	30.3	19.7	20.5	30.6	32.0
Spouse, age	do.	40.7	46.4	44.4	58.6	59.5	45.1	44.6	56.0*	58.9*
School completed	do.	12.2	12.7*	11.7*	11.0*	9.9*	11.8	12.3	11.7*	10.5*
Farm business:										
Gross sales	Dollar	84,916	17,406	12,962	6,206	5,701	114,187	128,272	38,384*	10,431*
Cash operating expenses	do.	58,561	18,215*	9,359*	6,621	4,987	91,515	78,338	25,779*	7,712*
Milk sales per cow	do.	1,479	—	—	—	—	—	—	—	—
Crop acres	Number	191	87	102	62	60	347*	690*	118	85
Dairy cows	do.	45	—	—	—	—	—	—	—	—
Financial resources:										
Total assets	Dollar	368,991	201,773	167,615	214,301*	146,018*	565,354	502,572	274,511*	179,766*
Total debts	do.	95,930	35,599	21,897	5,134	8,121	129,560*	75,957*	33,784*	5,854*
Net worth	do.	273,061	166,174	145,718	209,167*	137,897*	435,794	426,615	240,727*	173,912*
Debt/asset	Ratio	.26	.18	.13	.02	.06	.23	.15	.12*	.03*
Income source:										
Net cash farm operating	Dollar	20,808	–35*	3,713*	–99	872	21,715*	45,152*	12,029*	2,578*
Off-farm employment	do.	4,154	24,262*	18,446*	4,171	2,870	2,765	4,162	6,017	4,352
Unearned	do.	3,214	3,268*	913*	10,794*	4,544*	7,837*	1,935*	7,037*	4,411*
Total household income	do.	28,176	27,495	23,072	14,866*	8,286*	32,317*	48,249*	25,083*	11,341*
Viability ratio:										
Ratio under 1.00	Percent	47	18	17	32	54	42	45	3	9

*Values for which null hypothesis that Mississippi-Tennessee and Wisconsin means are equal has been rejected by use of a two-tailed t-test with significance level of 0.05.

— = Not applicable.

[1]Variables defined in glossary.

Households with Full-Time Operators and Smaller Farms (Sales under $20,000)

In both survey areas, operators of smaller farms and their spouses were close to retirement age and had less than a high school education. Many of these older operators were debt-free; the average debt-asset ratio was 0.02 in Wisconsin and 0.06 in Mississippi-Tennessee.

Farm size, measured by gross sales and crop acreage, was comparable in the two survey areas. Households generated an average of about $6,000 in gross sales on slightly over 60 crop acres. The average value of assets and net worth were higher for Wisconsin households.

Unearned income represented 73 percent of total household income in Wisconsin and 55 percent in Mississippi-Tennessee. Thirty-two percent of smaller full-time farms in Wisconsin had viability ratios under 1.0, compared with 54 percent in Mississippi-Tennessee.

Households with Full-Time Operators and Larger Farms (Sales of $20,000 or Above)

In each survey area, full-time operators of larger farms averaged 47 years of age, had a high school education, and 20 years of operating experience. These farmers averaged gross sales of $114,187 in Wisconsin and $128,272 in the Mississippi-Tennessee site. On average, Wisconsin operators generated comparable gross sales with fewer crop acres.

Average total assets and net worth were statistically equivalent for larger full-time farmers in the two sites. The average debt level was higher among households in Wisconsin than among those in Mississippi-Tennessee.

On average, higher debt levels on Wisconsin operations may have contributed to lower net cash income from farming. Wisconsin households received a higher absolute level and a greater proportion of their income from unearned sources. Although average household income was higher in the Mississippi-Tennessee survey area, the percentage of households with viability ratios under 1.0 is similar for the two regions (45 percent in Mississippi-Tennessee and 42 percent in Wisconsin).

Farm Exit Households

Operators planning to leave farming were close to retirement age, and they averaged over 30 years of farming experience. Farm size measured in terms of both sales and assets averaged larger in Wisconsin than in the Mississippi-Tennessee area. Wisconsin farmers averaged gross sales of $38,384 in 1982. Mississippi-Tennessee farmers averaged sales of $10,431 in 1980.

Households in the Wisconsin area reported average assets of $274,511 and equity of $240,727, compared with assets of $179,766 and equity of $173,912 among households in the Mississippi-Tennessee area. As a group, Wisconsin households had a greater debt burden, with an average debt-asset ratio of 0.12. Farm exit households in the Mississippi-Tennessee site had an average debt-asset ratio of only 0.03.

Despite their higher operating expenses and debt levels, households in Wisconsin generated over four times the net cash farm income from farming of those in the Mississippi-Tennessee area. The average level of unearned income was also higher among Wisconsin households. Households in Wisconsin received 48 percent of their total income from farming. In contrast, net cash income from farming represented only 23 percent of total income for households in the Mississippi-Tennessee area. Three percent of farm exit households in Wisconsin and 9 percent of those in the Mississippi-Tennessee area had viability ratios under 1.0.

Regression Model

The data presented in table 1 reveal differences in the level and composition of resources among farm household types and regions. Some of these human, farm business, and financial resource characteristics are hypothesized to be associated with household viability. To examine the relationship of household characteristics to viability, we analyzed farm households by group through regression analysis.

Farm Business Variables

Farm size can be represented by a variety of physical and financial measures. Gross sales of agricultural products, a conventional measure of size, reflects the physical volume of farm output weighted by product price. Crop acreage is a measure of size for many enterprises based on crop production. The value of household assets represents the quantity of real estate, livestock, machinery, and other assets, weighted by their market prices. To express several size measures in a compact form, we used gross sales, crop acres, and total assets variables to construct a standardized size index for each household group.[10]

The net effect of these farm size factors on household viability may be either positive or negative for dairy, part-time, or full-time operations. Although a higher value of assets improves the farm household's potential for obtaining operating and farm investment loans, many families who chose to expand

[10]We constructed a standardized size index through principal components analysis for each household group. This index is a factor score with a unique value for each household in the group. The factor score is a weighted sum of the household's gross sales, crop acres, and total assets.

their operations through debt-financing now encounter financial problems. For farm exit households, whose future flow of earnings has been estimated from the value of net worth, off-farm employment, and transfer income, greater farm size is expected to bear a strong and positive relationship to household viability.

We also hypothesized that farm business efficiency (output per unit of input) is positively associated with viability. However, the survey data usually did not permit construction of tenable efficiency measures because of heterogeneous product types. In the case of Wisconsin dairy farmers, who share a homogenous product and similar input mix, we included a proxy in the analysis. The proxy, an index of gross sales per dollar of purchased input, measures how effectively the farmer converted physical units of inputs (weighted by price and aggregated) into physical units of product (similarly weighted and aggregated). The following analysis terms this variable "farm productivity."[11]

Financial Resource Variables

The financial structure of the household affects current income through debt-servicing requirements. If income is held constant, households with a high debt burden in relation to assets must use more of their current income to meet interest and principal payments, leaving less income for consumption needs and capital replacement. Farm families with a high debt-asset ratio and poor repayment history may be refused financing by credit institutions. In the short run, these families can meet principal payments by reducing living expenses or foregoing capital replacement. They may be obliged to liquidate productive assets in the long run. The debt-asset ratio for any household type is a measure of financial structure and of credit risk and is expected to relate negatively to viability.

Human Resource Variables

We also hypothesized that human resources are associated with household viability. Empirical measures of these resources include years of farming experience and formal education of the operator, hours of nonoperator (that is, spouse or other adult) labor devoted to farm activities, whether or not nonoperators worked off the farm, and number of children in the household under age 16.[12]

"Years of farm-operating experience" expresses the effects of additional farming expertise gained during the early, human capital investment years of the farm operation. At a lower level of experience, associated with younger operator age, the effect of additional skills and expertise on viability is hypothesized to be positive and of relatively large magnitude. Over time, an additional year of farming experience contributes less to farming expertise. At the same time, debts accumulated during the earlier phases of operation are gradually retired, reducing debt-servicing requirements. The effects of these factors in farming experience should relate quadratically to household viability.

The number of children under age 16 may be associated with greater consumption needs and lower off-farm earnings while families attend to child-rearing and home production. During the child-rearing years, adult family labor is allocated to home production activities that are not measured in either farm or off-farm income. The number of younger children should be negatively related to viability.

Operator education should affect household viability positively to the extent that it increases labor productivity. To the extent that education, first, has a greater effect on returns to nonfarm labor than to farm labor and, second, acts as an "entry card" to certain nonfarm jobs, we may expect to see the strongest relationship in the case of part-time farmers.

The spouse of the farm operator and other adult household members can contribute to household income through farm or off-farm activities. These factors are measured by hours of nonoperator onfarm labor and by a binary variable indicating whether or not nonoperator household members worked off-farm during the survey year. Higher levels of either

[11]To avoid estimation problems resulting from correlation between dependent and independent variables, we used an index of relative efficiency in place of "sales per dollar of purchased input."

[12]Although use of a continuous variable representing hours of off-farm work would have been conceptually preferable, we chose a binary variable to avoid estimation problems.

farm or off-farm commitment should be associated with greater household viability.

Specification

The regression model is specified as:

$$Y = \beta_o + \sum_{i=1}^{9} \beta_i X_i + \epsilon$$

where:

Y = Viability ratio,
X_1 = Size index,
X_2 = Debt-asset ratio,
X_3 = Farm productivity (dairy farms only),
X_4 = Years of operator education,
X_5 = Years of operator farming experience,
X_6 = $(X_5)^2$,
X_7 = Nonoperator off-farm labor (1 = yes, 0 = no off-farm work),
X_8 = Hours of nonoperator onfarm labor, and
X_9 = Number of children under age 16.

The viability ratio compares total earnings with total financial obligations for each household. Differences in the variables X_1-X_9 should relate significantly to observed variation in the viability ratio. We applied the regression model separately to households in each group, assuming that the relationship of household characteristics to the viability ratio differs by group.

Wisconsin Area Results

Table 2 shows regression results for households in the Wisconsin area. Household groups include dairy farm households, households with part-time operators, households with full-time operators and smaller farms (sales under $20,000), households with full-time operators and larger farms (sales above $20,000), and households planning to leave farming.

Dairy Farm Households

Among dairy farm households, variation in the debt-asset ratio, farm productivity, operator education, years of operating experience, the decision to work off-farm by the spouse or other household members, and the number of young children are associated with variation in the viability ratio. The average dairy farmer in the Wisconsin site is young in relation to operators of other household groups and has a high school education and 17 years of experience (table 1). For these operators, regression results suggest that additional years of education are related to greater household viability. Although the effect of onfarm employment of the spouse and other household members is not significant, off-farm work is associated positively with household viability. As expected, higher debt-asset levels are associated with lower viability. Variation in the farm size index is not significantly related to viability. For these farm families, who receive 75 percent of their total income from net farm earnings (table 1), greater farm productivity contributes positively to household viability.

Among dairy farmers, regression results indicate that the viability ratio is negatively related to operating experience through 19.5 years and is positively related after 19.5 years.[13] This relationship may reflect the combined effects of accumulated technical expertise and gradual retirement of farm debts, but it may be dominated by the financially difficult circumstances of younger farm entrants with large debt loads in relation to their farm income. The life-cycle of the farm family, measured as the number of children under age 16, is negatively associated with viability. During the child-rearing phase of the family life cycle, relatively more of the total adult effort is used for home production and less for off-farm work or farm production.

Households with Part-Time Operators

Households in this group received 88 percent of their total income from off-farm earnings (table 1). Among these households, the debt-asset ratio, farm size, and operator education are significantly associated with the level of the viability ratio. A higher debt-asset ratio influences viability negatively. Additional operator education, which enhances employment opportunities, is associated with greater household viability. Larger farm size, which may constrain the ability to allocate labor off-farm, is associated with lower household viability. The data

[13]The first partial derivative of the function is zero at 19.5 years of operator experience.

Table 2—Farm household viability, by household group, 8-county Wisconsin area

Explanatory variable[1]	Coefficients[2]				
	Dairy	Part-time	Full-time		Exit
			Smaller	Larger	
Constant	0.689** (.369)	0.595 (.694)	3.245** (1.647)	1.257 (2.332)	3.850*** (1.272)
Size index	.042 (.049)	–.195** (.116)	–.385* (.129)	.081 (.309)	1.400*** (.203)
Debt-to-asset	–2.446*** (.235)	–1.398** (.740)	.629 (1.696)	–3.038** (1.583)	–4.727*** (1.429)
Farm productivity[3]	1.633*** (.164)	— —	— —	— —	— —
Operator education	.057*** (.024)	.088*** (.040)	.091 (.098)	.030 (.139)	.119* (.080)
Operator experience	–.039*** (.016)	.041 (.032)	–.121** (.068)	–.006 (.089)	–.012 (.044)
(Operator experience) squared	.001*** (.0004)	–.001* (.0006)	.001 (.001)	.001 (.001)	.00005 (.0007)
Nonoperator off-farm employment	.169** (.096)	.321 (.232)	.232 (.466)	1.107** (.625)	.092 (.387)
Nonoperator onfarm labor	.00002 (.00002)	–.00005 (.00007)	–.0003 (.0003)	–.0001 (.0001)	— —
Number of children under 16 years	–.108*** (.034)	–.082 (.086)	–1.049** (.589)	–.056 (.207)	–.133 (.241)
Number of observations	296	72	31	36	94
F	36.5	3.42	1.79	1.78	10.53
R^2	.52	.21	.17	.15	.42

— = Not applicable.
[1]Dependent variable is the viability ratio.
[2]Ordinary least squares estimates with standard errors in parentheses. Significance levels: 0.05***, 0.10**, and 0.15*.
[3]Measured for dairy farms only. Other groups were heterogeneous in terms of products and technology.

do not support the hypotheses that operator experience and nonoperator employment variables, as specified, are associated with viability.

Households with Full-Time Operators and Smaller Farms

Operators in this group were essentially debt free and near retirement age (table 1). The F-test for the group indicates that the joint effect of explanatory variables on the viability ratio is not significantly different from zero. Larger farm business size is associated with lower viability, suggesting that these smaller scale farm enterprises may suffer from production inefficiencies. All but two of the sample households in this group were debt-free, and differences in viability are not related to the debt-asset ratio. As in the case of dairy farmers, the number of children under age 16 is negatively associated with viability.

Households with Full-Time Operators and Larger Farms

Financial structure and nonoperator off-farm employment are associated with household viability among this group of households. The negative effect of the debt-asset ratio expresses financial obligations for both interest expenses and regular payments to retire debt. The positive effect of off-farm work by nonoperator adults indicates that even on larger farms, allocation of family labor to off-farm work can enhance viability. The separate effects of farm business size and other human resource variables, as specified, are not significant.

Farm Exit Households

The viability ratio for farm exit households expresses post-exit circumstances. Therefore, variables measuring farm productivity and onfarm labor hours of other adults in the family are not applicable to the analysis. In the Wisconsin area, the size of the farm operation has a large, positive effect on the viability of households planning to leave farming, and a higher debt-asset ratio has a large, negative effect. These results reflect the importance of net worth in determining the estimated future flow of income for exit farmers. With an average net worth of $240,000 and a mean age of 60 (table 1), this group is more representative of retiring farmers than of operators leaving the farm under financial duress. The positive effect of operator education may reflect the nonfarm employment alternatives available to the younger members of this exit group.

Mississippi-Tennessee Area Results

Table 3 shows regression results for households in the 29-county area of Mississippi-Tennessee. Household groups for this survey area include households with part-time operators, households with full-time operators and smaller farms (sales under $20,000), households with full-time operators and larger farms (sales of $20,000 or above), and households planning to leave farming.

Households with Part-Time Operators

The debt-asset ratio is negatively associated with viability among households in this group, as is the number of children under age 16. Higher levels of operator education positively influence viability, as does the presence of a nonoperator working off-farm. Similar effects of the debt-asset ratio and operator education were observed among households with part-time operators in the Wisconsin area. Years of experience as a farm operator is positively related to viability through about 15 years and negatively related after 15 years. This result may express the effect of advancing age (a correlated variable) on off-farm employment and wage rates.

Households with Full-Time Operators and Smaller Farms

As in Wisconsin, the F-test for this group indicates that the joint effect of the explanatory variables on viability is not significantly different from zero. Among the individual variables, only the debt-asset ratio (negatively related) and off-farm work by nonoperator adults (positively associated) are significant. Given the relatively low average income level among this group, it appears that nonfarm earnings by nonoperators are a key factor in enhancing viability.

Households with Full-Time Operators and Larger Farms

Among households in this group, only differences in farm size and the debt-asset ratio are associated with variation in household viability. If other factors are held constant, larger operations tend to have higher viability ratios, whereas households with higher debt-asset ratios tend to have lower ratios. Thus, the farm business appears to be the most important factor affecting viability. Changes in human resource factors, as specified, are not associated with variation in household viability.

Farm Exit Households

The viability of Mississippi-Tennessee households planning to leave farming is related to farm size, the debt-asset ratio, operator education, and nonoperator off-farm employment. (Similar relations between the explanatory variables and viability were observed in the Wisconsin area, except in the case of nonoperator off-farm employment.) The greater the size of operation (that is, the more assets available to generate a flow of asset income), the more viable the farm exit household will be. Conversely,

Table 3—Farm household viability, by household group, 29-county Mississippi-Tennessee area

Explanatory variable[1]	Coefficients[2]			
	Part-time	Full-time		Exit
		Smaller	Larger	
Constant	1.313***	0.933***	1.420**	1.412
	(.299)	(.319)	(.879)	(1.089)
Size index	-.072	-.113	.421***	1.450***
	(.062)	(.082)	(.150)	(.230)
Debt-to-asset	-1.872***	-.767**	-3.499***	-3.412***
	(.346)	(.469)	(.634)	(1.262)
Operator education	.085***	.012	.056	.308***
	(.018)	(.021)	(.056)	(.062)
Operator experience	.018	-.006	.017	.036
	(.016)	(.017)	(.037)	(.059)
(Operator experience) squared	-.0006**	.0002	-.00004	.0008
	(.0003)	(.0002)	(.0007)	(.0009)
Nonoperator off-farm employment	-.573***	.299**	.125	1.018**
	(.120)	(.181)	(.306)	(.526)
Nonoperator onfarm labor	-.0001	-.00004	-.00002	—
	(.00009)	(.0001)	(.0001)	—
Number of children under 16 years	-.314***	-.057	.091	-.243
	(.049)	(.080)	(.135)	(.371)
Number of observations	445	212	202	167
F	18.32	1.46	5.76	12.99
R^2	.24	.02	.16	.34

— = Not applicable.
[1]Dependent variable is the viability ratio.
[2]Ordinary least squares estimates with standard errors in parentheses. Significance levels: 0.05***, 0.10**, and 0.15*.

the higher the debt-asset ratio, the less viable the household will be. Higher levels of operator education (which express enhanced off-farm employment alternatives), as well as off-farm employment by nonoperator household members, influence viability positively. Both relationships suggest that the ability to earn nonfarm income will improve the viability of households exiting from agriculture.

Implications

The regression results are generally consistent with hypothesized relationships for all groups except households with full-time operators and smaller farms in both study sites. The latter group and households planning to leave farming represent special cases.

Smaller, full-time farmers in each survey area worked off-farm less than the equivalent of 4 weeks during the survey year and planned to continue farming over the next 5 years. On average, they grossed only about $6,000 in farm product sales. The typical operator was near retirement age (63-65 years old), free of debt, and received the largest proportion of total income from transfers, rents, interest, and other unearned sources. Attributes other than those included in the model presented here may be associated with viability. The inadequacy of the model in explaining variation among these families underscores their uniqueness.

Thirty-two percent of the smaller, full-time farm households in Wisconsin and 54 percent of these households in the Mississippi-Tennessee site had viability ratios under 1.0, or an annual income insufficient to cover farm and personal financial obligations during the survey year. These farm families would benefit from programs designed to help them close unprofitable farm businesses and convert farm assets into a dependable flow of retirement income. Some of these families may need information about their eligibility for Social Security, Supplemental Security Income, and Medicare/ Medicaid programs.

Changes in the capital gains aspects of tax policies and the development of institutions to facilitate the conversion of farm assets into a retirement income flow would improve their financial prospects. Such changes would also enhance the financial position of families planning to leave farming. In contrast to the smaller full-time farmers, only 6 percent of the farm exit households in the combined survey areas had viability ratios under 1.0. This percentage was higher in the Mississippi-Tennessee survey area, where both average unearned income and net worth are lower. Operators in these households also were older and less educated. For farm exit households, the results indicate that greater viability is associated with larger farm size, more farm assets, a lower debt-asset ratio, and off-farm employment by the spouse and other household members.

Other household groups planning to continue farming include Wisconsin dairy farmers, part-time farmers, and larger full-time farmers in both survey areas. Among these groups, the proportion of households with viability ratios under 1.0 is lowest for the part-time farmers (17 percent) in both survey areas. Almost 50 percent of dairy farmers have viability ratios less than 1.0. Among the full-time operators in both survey areas, slightly over 40 percent have ratios under 1.0. To continue operating the farm household under the year-of-survey organization, these families must either reschedule debts, forego capital replacement, or consume below the minimum level used in this analysis. Over the long run, farm-level adjustments will be necessary to sustain their operations.

Regression results provide evidence that the factors related to viability differ by farm household group. Farm size, measured by an index of gross sales, crop acreage, and the value of total assets, is associated positively with viability only for larger full-time farms in the Mississippi-Tennessee area and for farm exit households in both regions. The positive relationship of size to viability for farm exit households is explained by the importance of asset values in determining income flows after leaving farming. Among households planning to continue farming, results of the analysis suggest that farm growth strategies benefit only larger operations and only under particular conditions. For other groups in the sample, gains in returns from expansion may be offset by debt-servicing requirements or production inefficiencies. Greater farm size is associated with lower household viability among smaller full-time farmers and part-time farmers in the Wisconsin survey area.

A higher debt-asset ratio implies that a larger proportion of the annual income must be used to meet interest payments and payments toward loan retirement. The debt-asset ratio, a measure of the credit risk and financial structure of the farm household, is associated negatively with household viability for all household groups except the smaller full-time operations in Wisconsin. In that group, 29 of the 31 sample farms were debt free, and their debt-asset ratio was zero. Public initiatives to reduce interest rates, to guarantee farm loans, or to provide incentives for forgiving loans will affect the survival prospects for both full-time and part-time farmers during the adjustment to new product prices and interest rates. The effect on viability of a higher debt-asset ratio is greatest for larger full-time operations.

Years of operator education is associated positively with household viability among dairy farmers, part-time farmers, and exit farmers in both survey regions. Formal education affects household income by improving off-farm wage-earning potential. For part-time and exit farmers, a higher rate of off-farm earnings contributes both to current wage income and to the level of Social Security benefits available on retirement.

The positive and significant relationship between operator education and the viability ratio among dairy farmers may not express off-farm wage-earning capacity. Dairy farmers tend to work off-farm fewer hours than operators of other farm

types, and education may contribute instead to the operator's farm management skills. However, this effect was not observable in the analysis of smaller and larger full-time farmers in either survey area.

Regression results support the hypothesis that, for dairy farmers, years of experience are related quadratically to household viability. Through 19.5 years of experience, an additional experience is related to lower viability. After 19.5 years of operation, additional experience is related to higher viability levels. This relationship may reflect the counteractive effects of cumulative farming expertise and the financial conditions at the time the farm business was established. Although relatively high interest and principal payments on debt are characteristic of the early farming years, the regression coefficient for this variable may reflect particular historical circumstances. Operators entering the dairy business in more recent years were confronted with greater initial capital outlays that may have required costly debt-financing.

For five household groups, off-farm work by nonoperator household members is associated with greater viability, whereas an additional hour worked onfarm has no observable effect with any household group. Nonoperator off-farm employment is associated positively with household viability for each of the five groups, except part-time farmers in the Mississippi-Tennessee area. The magnitude of the effect varies greatly among the groups. Nonoperator onfarm hours, however, are not associated positively with household viability for any of the sample groups. In recent years, increasing numbers of farm families have chosen to increase their off-farm labor commitment. These results imply that more farm families may benefit from re-evaluating their present allocation of farm and nonfarm labor.

This study expresses the life-cycle stage of the farm family by the number of children under age 16 in the household. This variable reflects the obligation of adult family members to home production, as opposed to farm production or off-farm employment opportunities. The value of home production has not been measured in the viability ratio. The relationship of the life-cycle stage to farm household viability is significant for three of the household groups. Where significant, the effect of additional children under age 16 is negative, as expected.

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Appendix: Glossary

Crop acres include all land in crops, orchards, vineyards, nursery and greenhouse products, cropland diverted under Federal program guidelines, and acres used for pasture or grazing that are suitable for crops without improvements.

Debt-to-asset is the ratio of total farm and personal debts to total farm and personal assets, as of January 1 of the survey year.

Estimated annual income from value of net worth is the yearly amount of income a household planning to leave farming can expect to realize from the disposition of farm assets. Farm exit households with nonland assets sufficient to cover all debts are assumed to either rent the farm or sell the farm on land contract, depending on the option they specified in the interview. In addition to income from the sale or rental of their land, these households are expected to receive a 10-percent return on investment of their nonland assets.

Rental income is calculated at 6 percent of the market value of land assets. Income from land contracts is based on a 20-year agreement with equal annual

principal payments and 10-percent annual interest on the unpaid balance. We used Federal and State tax tables to estimate the after-tax income from land contract sales.

We assumed that households with debts exceeding the value of their nonland assets would liquidate the farm. To determine the net amount of money available for investment after liquidation, we subtracted both the value of all debts and the capital gains tax liability for the value of assets. Estimated annual income for households liquidating the farm is equal to 10 percent of after-tax earnings from the sale of the farm plus 10 percent of the value of remaining assets.

Estimated capital replacement costs were calculated at 10 percent of the value of all farm machinery, trucks, and cars.

Estimated minimum consumption is equal to the poverty threshold income level for the household, by household size and age of household head, as developed by the Bureau of the Census. For the purposes of this analysis, the household includes all individuals residing together at the time of the survey.

Estimated principal payments were calculated on the basis of the type of collateral under which individual loans were secured. Loans secured by real estate were assumed to have 20-year payback periods. Three-year payback periods were assumed for loans secured by personal property, and those secured by crop liens were assumed to have a 1-year payback period. If loans were not secured, the length of payback period was assigned according to the purpose of the loan: 20 years for real estate purchases, 3 years for production input purchases, and 2 years for household-related purchases. Annual payments were assumed constant over the life of the loan.

Estimated Social Security income was calculated for households in which either the spouse or the operator reached age 61 or over during the survey year. For persons at least 61 years of age at the time of the interview, the estimated Social Security payments were equal to their observed value. For persons who did not report benefits, we calculated estimates using Social Security Administration guidelines.

Estimated wage income was calculated on the basis of the age and off-farm employment experience of each household member. Persons over 64 years of age in the survey year were assumed to retire from off-farm work. Individuals between the ages of 50 and 64 were assumed to maintain the survey year level of off-farm work. Those under 50 years of age were assumed to begin working full-time off-farm when they left farming, whether or not they had worked off-farm in the past. For individuals who reported off-farm work in the survey year, the estimated wage rate was equal to the observed wage rate. For those who did not report off-farm work, the estimated wage income was equal to full-time earnings at the minimum wage rate.

Gross sales include all cash marketings of crops and livestock during the calendar year.

Cash income from farming is equal to the sum of gross sales plus farm-related income less cash operating expenses. Farm-related income includes receipts from custom work on other farms, gas tax refunds, patronage refunds, and Government grain storage programs.

Nonfarm earned income includes all household income from wage employment and net household income from self-employment in occupations unrelated to farming.

Nonoperator onfarm labor is equal to the annual hours of onfarm work by household members, excluding the farm operator.

Nonoperator off-farm labor is equal to the annual hours of work off-farm in nonfarm-related occupations by household members, excluding the farm operator. In the analyses, a dummy variable was used that was set equal to 1 if this variable was greater than zero, and to zero otherwise.

Off-farm employment income is equal to household income from wage and salary employment plus net income from nonfarm self-employment.

Other income includes public transfer payments, Social Security and private retirement income, rent, interest, and dividends.

Operator education is equal to the years of formal education of the farm operator.

Operator experience is equal to the operator's years of experience operating the survey farm or other farms.

Total household income is equal to the sum of cash income from farming plus off-farm employment income plus other income.

Transfer payments include pension and retirement income other than Social Security benefits, welfare and other public assistance, and unemployment insurance.

In Earlier Issues

Fingers were the first digital computers. The only really new thing about an electronic calculator is its fantastic speed. It does simple arithmetic literally at lightning speed. This places a premium on the development of such formal techniques as linear programming, input-output analysis, and the theory of games. These are high-powered analytical vehicles capable of using the speed.

Ronald L. Mighell and Burton L. French
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Optimization of Policy Goals in the Context of a Sector Model

By Nicole S. Ballenger and Roger D. Norton*

Abstract

This article investigates the possibilities of including policy choices directly into a sector model that simulates an economic equilibrium. It uses a mathematical programming framework because these models have wide applicability in agricultural sector analysis. The objective function is quadratic because the authors assume demand functions are linear. They formulate a policy choice model which they apply to Mexican agriculture.

Keywords

Policy modeling, mathematical programming, Mexican agriculture

Introduction

Incorporating a policy choice problem into a sector programming model directly is usually impossible because the sector model's objective function and constraint set are designed to simulate the equilibrium outcome of decentralized decisionmaking (*5*)[1]. Imposing a policy maximand on the model will destroy the simulating character of the outcome. Imposing policy constraints on the model will create a similar problem.

This article explores a special case in which the policy maximand and the market-simulating maximand coincide. They coincide when policymakers wish to maximize consumer plus producer surplus. Although the sum of surpluses is not a welfare measure in itself, Willig has shown that it can often be a good approximation of a true welfare measure (*13*).

The empirical problem formulated in this article is how to allocate a fixed Government budget to subsidies of several targeted crops in Mexico.[2] Given that the Mexican Government wishes to subsidize its agricultural sector to benefit both producers and consumers, a question arises about the most efficient allocation of crop subsidies. The analysis covers Mexico's eight principal crops: corn, wheat, sorghum, rice, soybeans, dry edible beans, safflower, and sesame. In analyzing the results, we give particular attention to the effects of policies on trade, because these crops have been assigned priority under recent Mexican programs aimed at attaining food self-sufficiency.

Methodology

Mathematical programming models have become progressively more sophisticated. The use of the programming framework is still limited, however, in terms of conducting systematic and comprehensive agricultural policy analyses. Although these models are useful in determining the impacts of specific policies, they are far less valuable in formulating complete statements of policy problems and in identifying "optimal" policy instruments.

The policy-cum-simulation problem is inherently a two-level maximization problem (*4*). A policy objective function is maximized subject to policy limits (such as budget constraints) *and* subject to maximization of the market-simulating objective function. This problem cannot be solved by normal mathematical programming algorithms; in fact, there is no procedure for obtaining the global joint

*Ballenger is an agricultural economist with the International Economics Division, ERS, and Norton is a professor of economics at the University of New Mexico.

[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

[2]We selected these crops because they might help achieve other objectives, such as food self-sufficiency, which are not explicitly stated in the model. If these other objectives are explicitly stated, then we must move from a single- to a dual-level programming framework to model the Mexican policy problem (*1*).

maximum. However, local point optima can be found in some cases (*3*).

In view of these difficulties, the typical procedure for analyzing policy options is to solve the sector model (with market simulating maximand) repeatedly, under different values of policy *parameters*. The consequences of different policies can thereby be explored. The literature contains numerous examples of this procedure (*2, 7, 12*). The procedure clearly requires prior specification of potentially interesting policy options; it does not permit formal maximization of a policy objective function. Nevertheless, economists have conducted some fairly systematic explorations of the "policy-feasible space" in this way (*1, 6, 10*).

Thus, policies are generally treated as exogenous in the usual sector model framework. For example, demand or supply functions are shifted to reflect taxes or subsidies, or tariffs are added to world prices. After these policies are incorporated, the solution can be interpreted as a market equilibrium under Government intervention.

Our approach, however, differs somewhat because the model itself determines values of policy variables. The objective function is still the maximization of producer plus consumer surplus. But, because the objective function contains policy choice variables, its purpose is no longer only to describe market behavior. It now describes the market's reaction to a given allocation of subsidy funds, and it simultaneously evaluates alternative outcomes and allocates subsidies in a way that maximizes the surpluses. The problem is essentially a two-level problem (*3*) which is collapsed to one level in this special case. If the public- and private-sector problems were to diverge (for example, if the policy problem were to maximize employment rather than producer and consumer welfare), then the one-level approach would no longer be valid and a two-level model would apply.

The "optimal" crop subsidy program will be a function of the Government decision rule (that is, the maximization of the net sum of producer plus consumer welfare), the set of policy instruments available to policymakers; the size of the Government budget; and the behavior of the private sector in response to Government intervention (namely, the implicit or explicit supply and demand functions). Thus, the interaction of the public and private sectors is especially important when the policy problem is formulated.

We formulated this "optimal" subsidy model for the small-country case with fixed costs and linear demands as follows:

$$\text{Max} \sum_i (a_i x_i^c + \tfrac{1}{2} b_i x_i^{c\,2}) - \sum_i c_i x_i^p + \sum_i s_i x_i^p + \sum_i p_i^e x_i^e - \sum_i p_i^m x_i^m \qquad (1)$$

Subject to:

$$Rx^p \leq \overline{r} \qquad [\lambda_j] \quad j = 1,\ldots,M \text{ resources} \qquad (2)$$

$$-x_i^p + x_i^c + x_i^e - x_i^m \leq 0 \qquad [\pi_i] \quad i = 1,\ldots,N \text{ crops} \qquad (3)$$

$$\sum_i s_i x_i^p \leq \overline{g} \qquad [\theta] \qquad (4)$$

$$s_i \leq \overline{s}_i \qquad [\phi_i] \quad i = 1,\ldots,N \text{ crops} \qquad (5)$$

The endogenous variables include:

x^c = a vector of quantities demanded;
x^p = a vector of quantities produced;
p^c = $a + bx^c$ = a vector of domestic consumer prices, where the matrix (b_i) is a diagonal matrix of demand slopes;
x^e = a vector of exports;
x^m = a vector of imports; and
s = a vector of output subsidies.

The exogenous variables include:

p^e = a vector of world prices for exports;
p^m = a vector of world prices for imports;
c = a vector of unit costs of production;
R = technology matrix, where r_{ji} is the quantity of the jth resource or input used to produce one unit of crop i;
$\overline{r}$ = a vector of resource constraints;
$\overline{g}$ = the Government budget constraint;
$\overline{s}$ = a vector of crop subsidy upper bounds; and
$\lambda, \pi, \theta, \phi$ = Lagrangian variables associated with the constraints.

Formulated in this manner, the model includes several new quadratic terms in the objective func-

tion and a quadratic budget constraint. Forming the Lagrangian results in the dual problem and the rules by which the optimal subsidy program is selected:

$$L = \sum_i \left(a_i x_i^c + \tfrac{1}{2} b_i x_i^{c\,2}\right) - \sum_i c_i x_i^p + \sum_i s_i x_i^p$$

$$+ \sum_i p_i^e x_i^e - \sum_i p_i^m x_i^m + \sum_j \lambda_j \left(\bar{r}_j - \sum_i r_{ji} x_i^p\right)$$

$$+ \sum_i \pi_i \left(x_i^m - x_i^e - x_i^c + x_i^p\right) + \theta \left(\bar{g} - \sum_i s_i x_i^p\right)$$

$$+ \sum_i \phi_i \left(\bar{s}_i - s_i\right) \qquad (6)$$

The main first order conditions are:

$$\frac{\partial L}{\partial x_i^c} = a_i + b_i x_i^c - \pi_i \leq 0 \qquad i=1, \ldots, N \quad (7)$$

or:

$$a_i + b_i x_i^c = \pi_i \qquad \text{for } x_i^c > 0$$

$$\frac{\partial L}{\partial x_i^p} = - c_i + s_i - \sum_j \lambda_j r_{ji} + \pi_i$$

$$- \theta s_i \leq 0 \qquad i=1, \ldots, N \quad (8)$$

or:

$$\pi_i = c_i + \sum_j \lambda_j r_{ji} + \theta s_i - s_i \quad \text{for } x_i^p > 0$$

$$\begin{bmatrix}\text{Shadow} \\ \text{price}\end{bmatrix} = \begin{bmatrix}\text{marginal} \\ \text{cost} \\ \text{of} \\ \text{production}\end{bmatrix} + \begin{bmatrix}\text{marginal} \\ \text{cost of} \\ \text{resource} \\ \text{use}\end{bmatrix} + \begin{bmatrix}\text{implicit cost} \\ \text{of budget} \\ \text{restriction}\end{bmatrix} - \begin{bmatrix}\text{output} \\ \text{subsidy}\end{bmatrix}$$

The first equilibrium condition states that, for each commodity, the implicit valuation, or shadow price, equals the market price. This is the usual equilibrium condition. The second first-order condition states that, for each commodity, the shadow price equals the marginal cost of production plus the implicit marginal cost of resource use plus the shadow price of the budgetary restriction minus the value of the crop subsidy. In other words, the price can now be less than marginal cost, by the amount of the subsidy, adjusted for the opportunity cost of budgetary funds.

Thus, the presence of policy variables in the model is reflected in the second first-order condition. Equilibrium prices are modified by the subsidies and the shadow value of the Government budget constraint. The figure depicts an output subsidy for a single commodity and its impact on the equilibrium price.

In the figure, q^o is the unsubsidized market equilibrium quantity, and q^s is the quantity when a subsidy s is in effect. The price symbols are:
p^p = producer price, p^o = unsubsidized market price, and p^c = consumer price.

The figure is a conventional diagram of market equilibrium under a subsidy with one exception: the difference $(p^p - p^c)$ is no longer equal to the nominal subsidy, but rather to the true subsidy, taking into account the opportunity cost of Government funds. Relating the figure to equations (7) and (8), we have:

$$p^p - p^c = s(1 - \theta) \qquad (9)$$

where the subscript i has been dropped for convenience.

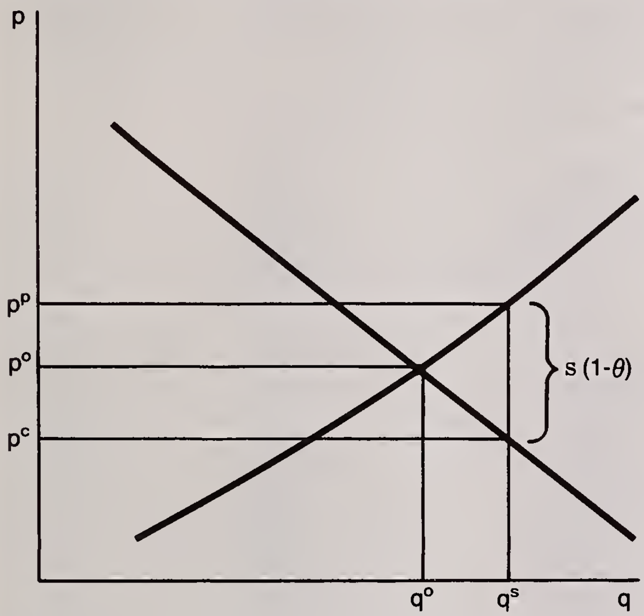
Equation (9) follows because equation (7) says that $\pi_i = p_i^c$ and equation (8) says that $\pi_i = p_i^p - s(1 - \theta)$.

Application to Mexican Agriculture

The sector model used for this research is described in detail in (*1*).[3] It was adapted from the World Bank's model of Mexican agriculture (CHAC) (*11*).

[3]The development of the technical coefficients and demand parameters for the original 1968 CHAC model is well-documented (*11*). The technical coefficients and resource constraints were updated to 1980 for this research based primarily on aggregate trends. Price elasticities of demand were assumed fairly stable over time. Income elasticities were derived from several sources (*1*).

Modified Equilibrium under Subsidies



The model's base solutions were good representations of actual supply and demand in Mexican agriculture in both 1968 and 1980. The base variants were modified subsequently to form the optimal subsidy version.

Whereas the original CHAC model was expressed in a linear programming format through a linear approximation procedure (*11*), the quadratic terms of our model have not been approximated. The model was solved with MINOS, a mathematical programming algorithm that uses a reduced gradient method for solving large-scale problems with nonlinearities in the objective function and/or the constraint set (*9*).

In modifying the original model, one needs two kinds of parameters: the total subsidy budget available ($\bar{g}$ in equation (4)) and the upper limits on subsidy rates by crop ($\bar{s}_i$ in equation (5)). We arbitrarily varied the values of these parameters in different solutions. We used three sets of illustrative values, which were not unrealistic for Mexican agriculture and policy in 1980 to define the following three main alternative solutions:

Case	Total subsidy budget	Upper bounds on crop subsidies
	Billion pesos	
1	25	1,000 pesos/ton[1]
2	25	40 percent of equilibrium prices
3	35	40 percent of equilibrium prices

[1]At 1980 prices, the 1,000-peso subsidy limit represented the following percentage subsidies of base-year prices: sorghum, 29; corn, 28; paddy rice, 27; wheat, 23; soybeans, 16; safflower, 13; beans, 9; and sesame, 5.

Tables 1-6 present the three alternative solutions. In case 1, the model chose seven of eight targeted crops–rice, safflower, dry beans, sesame, corn, sorghum, and wheat—to subsidize at the upper subsidy limit. Total subsidies to the three most important targeted crops—corn, sorghum, and wheat—are clearly the largest; therefore, they make the largest contributions to the value of the objective function. Tables 1 and 2 also show that allocating subsidies to these three crops increases their total supplies. Corn output increases 13 percent over the equilibrium solution with no subsidies; sorghum output increases 4 percent; and wheat output increases 14 percent. However, output decreases for the other four subsidized crops. Both rice and safflower output decline 5 percent; dry edible bean output declines 6 percent; and sesame output falls 37 percent. Sesame exports also decline 40 percent. These declines occur because the crop substitution effects are stronger than the output effects of the subsidies.

The supplies of alfalfa, sugarcane, barley, and cotton, and of nontargeted crops not eligible for subsidies decline significantly in absolute terms. Small absolute declines, but large percentage reductions, are indicated for minor crops such as lima beans (–15 percent) and flaxseed (–62 percent). Declines in total output of important export crops (tomatoes, melons, and vegetables) range from only 1 percent to 6 percent;[4] strawberry output declines slightly more (10 percent).

[4]We assume that Mexico is a price-taker in all foreign commodity markets. This assumption is unrealistic in the case of most fresh vegetable and fruit trade, especially in the winter months when Mexico's production competes with Florida's production for the U.S. market. Other research based on CHAC focuses on the fresh vegetable- and fruit-producing regions of Mexico and relaxes the small-country assumption (*12*).

Table 1—Case 1: Commodity impacts of subsidy program[1]

Crop	Subsidies: Solution	Subsidies: Upper bound	Consumption	Exports	Imports	Production	Change in production from base solution[2]
	Pesos per ton		*1,000 tons*				*Percent*
Garlic			47.3	15.0		62.3	–1
Alfalfa			17,033.0			17,033.0	–6
Cotton			1,814.4	175.0		1,989.4	–4
Rice	1,000	1,000	606.8			606.8	–5
Sugarcane			13,926.2		400.0	13,526.2	–12
Squash			224.3			222.43	–2
Safflower	1,000	1,000	411.0			411.0	–5
Peanuts			166.4			166.4	–6
Onions			205.7	100.0		305.7	–1
Barley			650.7		200.0	450.7	–22
Dry chili			30.3	5.0		35.3	NC
Green chili			224.4	20.0		244.4	NC
Strawberries			161.4	60.0		224.1	–10
Beans	1,000	1,000	960.2			960.2	–6
Chick peas			347.5	100.0		447.5	NC
Lima beans			50.4			50.4	–15
Tomatoes			902.7	355.0		1,257.7	–1
Sesame	1,000	1,000	75.0	60.6		135.6	–37
Flaxseed			21.3		17.0	4.3	–62
Corn	1,000	1,000	9,840.4		242.6	9,597.8	13
Cantaloup			295.4	100.0		395.4	–5
Potatoes			745.4			745.4	–1
Cucumber			51.2	150.0		201.1	NC
Watermelon			615.7	100.0		715.7	–6
Sorghum	1,000	1,000	4,344.8			4,344.8	4
Soybeans	0	1,000	557.4		557.4	0	NC
Wheat	1,000	1,000	3,769.6			3,769.6	14

Blanks indicate not applicable. NC = No change. [1]Total available budget is 25 billion pesos. Individual subsidies limited to 1,000 pesos per ton. [2]Base model solution is the equilibrium solution with no subsidies.

Table 2—Case 1: Policy impacts of subsidy program[1]

Item	Unit	Amount	Change from base[2]
			Percent
Budget	10 million pesos	1,929.8	
Objective	do.	42,012.7	5.0
Exports	do.	1,399.0	5.0
Imports	do.	547.8	–50.0
Net trade	do.	851.2	120.0
Employment	1,000 work years	2,471.8	.6
Food grains	1,000 tons	13,367.4	13.5
Consumer surplus	10 million pesos	28,174.4	–9.0
Sector income	do.	13,982.6	51.0

Blanks indicate not applicable. NC = no change. [1]Total available budget is 25 billion pesos. Individual subsidies limited to 1,000 per ton. [2]Base model solution is the equilibrium solution with no subsidies.

Our conclusion is that important crop substitution occurs in Mexico among crops in the basic grain and oilseed group. Substitution between crops in this group and most major export crops is less important. Furthermore, the fact that production of some subsidized crops declines highlights the importance of considering the price ratios among targeted crops (as well as between targeted and nontargeted crops) when one formulates a crop subsidy program. In other words, if a goal of this subsidy program had been to stimulate output of all targeted crops, as was the case for the Sistema Alimentario Mexicano (SAM) program, the desired objectives would clearly not have been met.

Tables 3 and 4 present the results when the total budget constraint is again 25 billion pesos, but

Table 3—Case 2: Commodity impacts of subsidy program[1]

Crop	Subsidies: Solution	Subsidies: Upper bound	Consumption	Exports	Imports	Production	Change in production from base solution[2]
	Pesos per ton		1,000 tons				Percent
Garlic			47.8	15.0		62.8	NC
Alfalfa			18,083.9			18,083.9	NC
Cotton			1,892.3	175.0		2,067.3	NC
Rice	1,464	1,464	636.2			636.2	NC
Sugarcane			15,723.4		400.0	15,323.4	NC
Squash			227.8			227.8	NC
Safflower	0	3,123	432.5			432.5	NC
Peanuts			181.6			181.6	NC
Onions			209.1	100.0		309.1	NC
Barley			691.3		115.7	575.6	NC
Dry chili			30.4	5.0		35.4	NC
Green chili			225.2	20.0		245.2	NC
Strawberries			189.2	60.0		249.2	NC
Beans	1,279	4,349	1,025.4			1,025.4	NC
Chick peas			347.5	100.0		447.5	NC
Lima beans			59.5			59.5	NC
Tomatoes			918.9	355.0		1,273.9	NC
Sesame	0	7,436	115.4	100.0		215.4	NC
Flaxseed			28.2		17.0	11.2	NC
Corn	1,412	1,412	9,840.4		1,356.3	8,484.1	NC
Cantaloup			318.2	100.0		418.2	NC
Potatoes			752.0			752.0	NC
Cucumber			52.0	150.0		202.0	NC
Watermelon			658.6	100.0		758.6	NC
Sorghum	1,357	1,357	4,163.0			4,163.0	NC
Soybeans	0	2,537	557.4		557.4	0	NC
Wheat	1,777	1,777	3,714.2		418.9	3,295.3	NC

Blanks indicate not applicable. NC = No change. [1]Total available budget is 25 billion pesos. Individual subsidies limited to 40 percent of equilibrium prices. [2]Base model solution is the equilibrium solution with no subsidies.

Table 4—Case 2: Policy impacts of subsidy program[1]

Item	Unit	Amount	Change from base[2]
			Percent
Budget	10 million pesos	2,500	
Objective	do.	42,655	6.2
Exports	do.	1,479.2	NC
Imports	do.	1,091.8	NC
Net trade	do.	387.4	NC
Employment	1,000 work years	2,456.5	NC
Food grains	1,000 tons	11,779.4	NC
Consumer surplus	10 million pesos	31,023.7	NC
Sector income	do.	11,774.6	27.0

Blanks indicate not applicable. NC = no change. [1]Total available budget is 25 billion pesos. Individual subsidies limited to 40 percent of equilibrium prices. [2]Base model solution is the equilibrium solution with no subsidies.

when individual crop subsidies are limited to 40 percent of the current market price. (For example, the subsidy limit on corn is 1,412 pesos per ton, which is 40 percent of the equilibrium price generated with the sector model in the absence of Government intervention.) The optimal allocation of the budget is to subsidies of corn, sorghum, wheat, and rice (which are subsidized at the upper limit) and to dry beans (which are subsidized below the upper limit). However, soybeans, sunflower, and sesame are not subsidized. This solution makes it clear that when the subsidy limits are raised, it is optimal to specialize the subsidy policy and confine it to fewer crops. (The objective function's value is higher in case 2 than in case 1.) Byproducts of that specialization are lower employment and lower net imports.

Table 5—Case 3: Commodity impacts of subsidy program[1]

Crop	Subsidies		Consumption	Exports	Imports	Production	Change in production from base solution[2]
	Solution	Upper bound					
	Pesos per ton		*1,000 tons*				*Percent*
Garlic			47.2	15.0		62.2	–1
Alfalfa			16,029.0			16,029.0	–11
Cotton			1,745.2	175.0		1,920.2	–7
Rice	1,464	1,464	612.8			612.8	–4
Sugarcane			13,651.6		400.0	13,251.6	–14
Squash			222.8			222.8	–2
Safflower	3,123	3,123	437.5			437.5	1.1
Peanuts			160.1			160.1	–12
Onions			204.8	100.0		304.8	–1
Barley			638.0		200.0	438.0	–24
Dry chili			30.2	5.0		35.2	–1
Green chili			224.1	20.0		244.1	NC
Strawberries			161.1	60.0		221.1	–11
Beans	4,349	4,349	1,029.0			1,029.0	.35
Chick peas			347.5	100.0		447.5	NC
Lima beans			49.6			49.6	–17
Tomatoes			889.2	355.0		1,254.2	–2
Sesame	7,436	7,436	144.1	100.0		244.1	13
Flaxseed			17.0		17.0		–100
Corn	1,412	1,412	9,840.4		439.8	9,400.6	11
Cantaloup			287.0	100.0		387.0	–7
Potatoes			737.7			737.7	–2
Cucumber			50.4	150.0		200.4	–1
Watermelon			607.9	100.0		707.9	–7
Sorghum	1,357	1,357	4,399.7			4,399.7	6
Soybeans	0	2,537	557.4		557.4	0	NC
Wheat	1,777	1,777	3,714.2		61.3	3,652.9	10.9

Blanks indicate not applicable. NC = No change. [1]Total available budget is 35 billion pesos. Individual subsidies limited to 40 percent of equilibrium prices. [2]Base model solution is the equilibrium solution with no subsidies.

Table 6—Case 3: Policy impacts of subsidy program[1]

Item	Unit	Amount	Change from base[2]
			Percent
Budget	10 million pesos	3,315.6	
Objective	do.	43,370.4	8.0
Exports	do.	1,479.2	NC
Imports	do.	644.7	–41.0
Net trade	do.	834.5	115.0
Employment	1,000 work years	2,462.4	.2
Food grains	1,000 tons	13,053.5	10.8
Consumer surplus	10 million pesos	26,566.0	–14.0
Sector income	do.	16,948.3	83.0

Blanks indicate not applicable. NC = no change. [1]Total available budget is 35 billion pesos. Individual subsidies limited to 40 percent of equilibrium prices. [2]Base model solution is the equilibrium solution with no subsidies.

Tables 5 and 6 show that when the budget constraint is increased to 35 billion pesos (and individual subsidy constraints remain at 40 percent of market value), it is possible to include all targeted crops, except soybeans, in the subsidy program. It also becomes "optimal" to increase production of all subsidized crops, except rice, at the expense of production of nontargeted crops. Again, the most important substitutes are alfalfa, sugarcane, barley, and cotton, which register the largest absolute declines. There are important percentage shifts from lima beans, flaxseed, strawberries, and peanuts. In this case, too, the impact on other export crops is marginal; production decreases 1-6 percent.

In all three cases, the subsidy expenditures reallocate welfare between consumers and producers, and they benefit producers. The apparent cause is that supplies are reduced for many more crops than they are increased. With demand functions that are generally price-inelastic, coupled with import restrictions, this effect raises producer incomes and lowers consumer welfare. Thus, the optimal subsidy programs lead to price and quantity adjustments that bring about a higher level of the sum of surpluses, but lower aggregate consumer welfare. (This result does not occur for all crops individually.) This finding may suggest that maximization of the sum of surpluses, with no distributional weights, may not be the goal that most policymakers would prefer.

Implications

Some tentative policy-oriented conclusions emerge from our analysis:

1. Maintaining relative price ratios among crops targeted for self-sufficiency is important if supplies of all targeted crops are to increase; otherwise, substitution in the production of these crops can decrease the output of some of them.

2. Programs designed to subsidize the producers of this targeted set of basic commodities appear to have positive effects on most goals of Mexican policymakers, which include increasing employment, food grain production, and net foreign exchange earnings (because import cost savings outweigh lost export earnings). But, these programs have net negative impacts on total consumer surplus. (This analysis does not tell us how different consumer groups are affected.)

3. Larger allocations of public funds to subsidy programs, although clearly able to generate additional sector income, do not necessarily imply additional benefits in terms of other Government goals. For example, the 33-billion-peso subsidy program (tables 5 and 6) sets off a chain of crop substitution effects which had smaller positive employment impacts than the 19-billion-peso program (tables 1 and 2). Thus, one policy goal, such as increasing producer income, can be inconsistent with another, such as generating additional farm employment.

Furthermore, the analysis suggests a number of implications for U.S.-Mexican trade and competition:

1. Output price subsidies for the targeted crops, of the magnitude considered in this study, appear to have little impact on the supply and export of many fresh horticultural products. Cotton and sesame are the Mexican export crops for which substitution with grains is most important. Thus, Mexico's role in world cotton markets would continue to diminish under this policy scenario.

2. Mexican price policies considered here would reduce grain and oilseed imports, at least in the short run. However, grain imports would not be eliminated or even dramatically reduced by the use of these policy instruments alone.

3. Because of production substitution between food (corn and wheat) and feed grains, the relative prices of subsidized crops in Mexico could have important implications for the composition of grain and other basic commodity imports.

Finally, this analysis has demonstrated that there are workable opportunities for policy analysis with sector programming models that agricultural economists have barely explored. Our analysis strongly suggests, however, that when multiple crops are involved in the setting of policies, one cannot predict *a priori* the net effects of the overall policy package on some national economic goals. Hence, a detailed numerical analysis is necessary for a full exploration of policy consequences.

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Research Review

The Growth and Structure of International Trade Since the Second World War

Lyndon Moore. Totowa, NJ: Barnes & Noble Books, 1985, 393 pp., $34.95.

Reviewed by Stephen W. Hiemstra*

If everyone is an economist, then since 1980 every economist has become a trade economist. Changes in the international economy these past 5 years—economic recession, voluntary export restraints on various consumer goods, and financial distress—have profoundly affected everyone. Economists accordingly need to review their assumptions about how the world works. This need brought about Lyndon Moore's book, *The Growth and Structure of International Trade Since the Second World War.*

Moore's objective is to analyze the growth and composition of international trade since the war (pp. 4-5). She pursues this objective in three major sections. The first section reviews the history of agricultural, trade, commercial, and financial policies and the institutions set up to implement them. The second summarizes trade theory. The third section analyzes trade in agricultural commodities, fuels, textiles and clothing, and automobiles. Analysis of the effects of protectionism on employment and economic growth is an important theme throughout the book (pp. 3-4). .

In developing this theme, Moore sees a conflict between the stabilization and growth objectives pursued in public policies (pp. 3-4). Stabilization objectives pursued in macroeconomic and commercial trade policies are designed to maintain full employment. Growth objectives pursued in market structure and free trade policies serve to maximize the benefits of the specialization permitted by participation in the world market. Although these objectives are compatible over the long term, workers must often be retrained and seek new jobs to achieve the level of specialization necessary to compete in world markets in the short run. A tension between these objectives therefore emerges, suggesting that the gains from trade are as unequally distributed as resource endowments (p. 367).

Although the book is encyclopedic in its scope, Moore did not intend to write a textbook. Rather, she states in the preface she wrote the book to present trade patterns, history, and theory to policymakers. Viewed against this objective, she succeeds. The book presents simply and concisely the basic information generated by economic research over the years on trade problems. It accordingly best meets the need of the policymaker who is not by training an economist.

Although trade economists may often need to widen the scope of their reading, some may find this book lengthy and inconclusive. In analyzing the observation that major traders have begun to question the merits of free trade, for example, Moore makes only passing reference to the complaints of developing countries about the changing terms of trade (p. 367). Other hypotheses which might follow from her analysis—a slowing of the rate of technological advance or a slower growth rate as a consequence of adjustment to an already widened world market—are not considered. The book, therefore, falls short of its potential. Notwithstanding, most economists would benefit from reading the chapters on effects of technological change and foreign investment on trade.

*The reviewer is an agricultural economist with the International Economics Division, ERS.

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